#49
Report.
LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

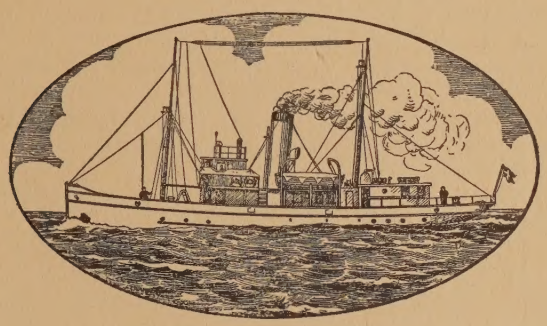
Report

of

The Danish Biological Station

to

The Ministry of Agriculture and Fisheries



XLIX.

1946

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1949.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

XXI. *C. G. Joh. Petersen:* Valuation of the Sea. II. The Animal Communities of the Sea Bottom and their importance for marine Zoogeography. With 6 Plates, 3 Charts and an Appendix. 110 pp. 1913.

XXII. I. *P. Boysen Jensen:* Studies concerning the organic matter of the Sea Bottom. II. *H. Blegvad:* Food and Conditions of Nourishment among the Communities of invertebrate animals.

*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

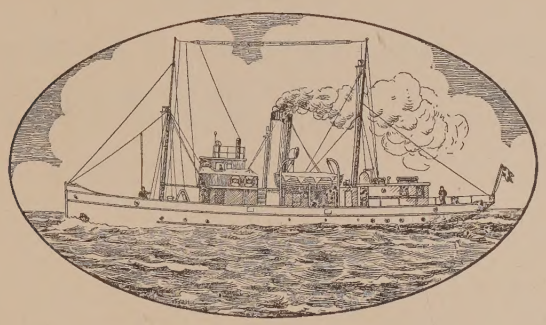
Report

of

The Danish Biological Station

to

The Ministry of Agriculture and Fisheries



XLIX.

1946

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1949.

CONTENTS

Page

Erik M. Poulsen: Seine Fishery for Small Herring and Sprat in the Limfjord..... 3

Knud Larsen: First Report on the Effect of the Liberation of Salmon Fry in the Gudenaa 1946—47 27

Seine Fishery for Small Herring and Sprat in the Limfjord.

By

ERIK M. POULSEN

CONTENTS

	Page
Introduction	5
1. Gears	5
2. Catching localities	8
3. Yields of catches	9
4. On the quantities of the different fishes and their size in catches from sprat seines and sprat trawls and on the influence of the fishery with these gears on the fish population of the Limfjord	11
Conclusion	24

Introduction.

Through several centuries seines have been used for catching herring fishes in the Limfjord. Both in former times and nowadays the catches of this seine fishery include not only larger herring but also small herring of 6—16 cm length and sprat. Very often small herring and sprat (both young and adult fish) constitute the bulk of the catch, thus giving it the character of waste fish because a considerable part of it (the small herring and the small sprat) is not used for human food but for industrial purposes (for the production of fish meal, fodder for pond fish and bait).

In older times herring seines (shore seines) were used for this fishery; in modern times sprat seines and sprat trawls are nearly the only gears in use. These two gears have a very small mesh-width, and so there is a possibility that they will take large amounts of young fish, primarily the youngs of herring and sprat, but also the youngs of other commercial fishes like cod and flat-fish. In order to find out the extent to which this seine fishery influences the stock of young fish in the Limfjord the Biological Station for about 10 years has been examining samples—forwarded by the Fishery Inspection—of catches taken in these seines. The following is a detailed comment on this seine fishery and on the results of the examination intended to clear up what fishes and what size groups of fish are contained in the catches.

1. Gears.

Far back in history we find records of herring fishery in the Limfjord; in reports from the time of Kristian II—the beginning of the 16th century—the herring seine is mentioned among the gears used in the herring fishery, and up to 1917 this was the only seine gear used for fishing herring; of course this does not exclude the possibility that small herring and sprat were taken in other seines, for instance eel seines. The herring seine was used nearly exclusively as a shore seine; in the ordinances concerning the Limfjord fishery special localities for the drawing of seines were assigned along the narrows of the Fjord, and in these localities the herring seines must not be disturbed by other fisheries. Mortensen & Strubberg, 1935[1]) describe the herring seine in this way: "Herring seines are large land seines with long and deep arms. The bag is 12—20 m long, the height at the mouth varying from 3 to 10 m or more. The arms are 60—85 m long. The Limfjord seines have a longer bag and shorter arms. The mesh-width of the bag is about 12—15 mm, about 20 mm in the seines of the west coast. The cod-end may show a smaller mesh-width. Dragging lines about 400—800 m for each arm."

The first known ordinances on the herring seine (and other gears) date from the time of Kristian II, who in 1515 issued a decree "On fishery in the Limfjord", which i. a. says that "In the same way nobody is allowed to use so small meshes of herring seines or other fishing gears, that the herring taken in them are so small, that they are no good for salting or selling."[2]) The last sentence seems to show that the King or his advisers in this decree did not so much intend to protect the young fish as to secure the salting and sale of a proper-sized herring. The other "gears" used then were weirs, pound-nets and bar nets. In a decree issued by Kristian III from 14.2.1546 on the fishery in the Limfjord it is ordained that "A Skælde" (to be explained below) shall be made and hung up at the town-hall of all towns at the Limfjord, according to which everyone must bind his pound-nets, weirs, bar nets, funnels of seines and other nets.[2]) The same regulation is found in the "Danish Law of Kristian V" from 1683. None

[1]) F. V. Mortensen & A. C. Strubberg: Dansk Saltvandsfiskeri, Copenhagen 1935.

[2]) Quoted from M.: Attempts at a survey of older and newer laws on the fishery in Denmark. In Danish. Tidsskr. for Fiskeri, 2. Aarg., Copenhagen 1868.

of these decrees mention the size of the "Skælde". The "Skælde" was in use down to our times as a standard of mesh-width. It mostly consisted of a cylindrical piece of brass divided into several sections with various diameters corresponding to the different mesh-widths. The circumference of this gauge corresponds to half the mesh-width: without straining the two central knots of the mesh must be able to meet when the prescribed section of the gauge is put into the mesh. This very old gauge is mentioned for the last time in the Fisheries' Act of 1917, later acts giving the length in mm from knot to knot as a standard of mesh-width.

In the Limfjord Act of 1857 it is determined that the gauge for the funnel or chock of the herring seine must have a circumference of "20 Linjer" (1 Linje = $^1/_{16}$ of a Danish inch), which corresponds to a mesh-width of about 20 mm from knot to knot; the cod-end of the bag might have a mesh-width of only 15 mm, and the mesh-width of the arms must be 21 mm.

This small mesh-width shows that the herring seines were meant to catch not only large herring but also small herring and sprat. In other words the fishing of waste fish is of old date in the Limfjord.

According to the Fisheries' Act of 1888 herring seines to be used in the Limfjord must have the following mesh-widths (from knot to knot): the arms 21 mm, $^2/_3$ of the bag from the mouth 20 mm and the cod-end 15 mm. It is further provided that the necessary weights of the seine must be attached to it by means of straps and not be bound immediately to the seine: already at that time it was acknowledged that this fine-meshed gear should not be made in such a way that too many youngs of the bottom fishes were removed. Another paragraph says that no herring seine during its use must reach beyond the mid-stream line; this shows us that the herring seine was mostly—perhaps exclusively—used as a shore seine. The use of the gear was permitted from Oct. 10th to June 15th.

In the Fisheries' Act of 1907 the mesh-width was fixed at 21 mm in the arms, 20 mm in the front part of the bag and 15 mm in the cod-end; it was further provided that between Oct. 15th and March 31st it was permitted to use a mesh-width of only 12 mm in the hindmost $7^3/_4$ m of the bag.

In the Fisheries' Act of 1917 the same mesh-widths are stipulated as in the 1907 Act (21 mm in the arms, 20 mm in the front part of the bag and 15 mm in the cod-end), but there is an addition to the effect that "from Oct. 15th to March 31st it is allowed in herring seines to use smaller mesh-widths than those mentioned above". In other words there is now no minimum size of mesh of the bag during the winter half-year, but at the same time the Act says that herring seines may be used as shore seines only.

The Fisheries' Act of 1931, finally, cancels all regulations of mesh-width, but still it is only permitted to use the seine as a shore seine, and there are to be straps between foot-rope and weight.

The regulations of the different acts show that as the time went the herring seine changed from a rather wide-meshed gear mostly used for catching grown-up herring into a small-meshed gear primarily determined for the catching of small herring and sprat.

But in spite of these alterations in the structure of the herring seine this very old gear during these 30 years has come to play an ever decreasing part in the fishery. In 1860 about 40 herring seines were in use in the Limfjord, in 1900—1920 about 60—70. From 1920 the number fell rapidly, and at present only about a dozen herring seines are used in this water. This decrease is evidently due to two causes. One is that another gear, the herring pound-net, in the course of the years has come to prevail in the herring fishery, as will appear from the following survey of the changing number of herring seines and herring pound-nets and of their catch yields in Danish Kroner:

	Herring seines		Herring pound-nets	
	No.	Kr.	No.	Kr.
1879—80	38	24 000	286	9 000
1890	58	43 000	233	19 000
1900	53	80 000	201	37 000
1910	71	76 000	377	92 000
1920	65	243 000	378	539 000
1930	6	11 000	703	166 000
1939	9	3 000	363	365 000

About 1880 the herring caught in seines had more than twice the value of those caught in pound-nets, and this was still the case about 1900, but in 1910 nearly the same amounts were caught by both gears. In 1920 twice as many herring were taken in pound-nets as in seines and from this year the decrease of the seines is rapid; in 1939 the catches of the pund-nets are more than 100 times as valuable as those of the seines. It is remarkable that the number of

pound-nets did not rise very much from 1880 till our days—from 286 to 363 only—but it should be remembered that the pound-nets of to-day are much larger and much more efficient than those used at the end of the last century; the size increase of the pound-nets from 1880 to 1939 appears from the following comparison of their values:

	1890	1939
1 seine	700 Kr.	500 Kr.
1 pound-net	160 -	900 -

The other cause of the decreasing importance of the herring seines during later years is that other and better gears for the catching of small herring and sprat, the sprat seine (often called cod seine) and the sprat trawl, were invented, and that the introduction of motor power in the fishery enabled seines to be used to a much greater extent than in the days of the rowing and sailing boats.

The Fisheries' Act of 1917 made the so-called cod seine a legitimate gear in the Limfjord[1]). This gear may be used from Dec. 1st to Feb. 28/29th. The mesh-width of this seine must no be less than 39 mm in square (from knot to knot) and the weights must be attached by straps of at least 21 mm length. In May 1923 an alteration of the act abolished the minimum mesh-width, and another alteration of the act in 1925 extended the time during which the seine might be used to Sep. 1st—Apr. 30th. In the 1931 Act the period for the use of this purse seine was limited to Nov. 1st—Feb. 28/29th but a minimum mesh-width was not introduced again.

The alteration of the Fisheries' Act in 1923 involved that from now on the so-called cod seine could be made with as small meshes as was desired. The consequent change in the construction of the seines apparently was connected with a desire of also—and perhaps principally—using this seine for the catching of small herring and sprat. It has turned out that the cod population of the Limfjord had suffered a very pronounced decrease between 1919 and 1923: during these years the yield of the cod fishery fell from 1100 to only 200 tons. In other words the seine fishing for cod alone would hardly pay any more, but if the mesh-width, particularly of the bag, was altered, the many recently purchased cod seines could be made fit for fishing small herring and sprat. Already in 1923 more than 1 mill. kg of small herring were stated to have been caught in cod seines as against only 160 000 kg of cod, and after that time the cod seine to a great extent has been used for catching small herring and sprat though it is not mentioned in the Fisheries' Act among the gears provided for this purpose. In 1935, however, a notification from the Ministry deals with this gear allowing[1]) a purse seine to be used between Nov. 1st and April 15th with a mesh-width of at least 39 mm in the arms and at least 10 mm from knot to knot in the bag. Within the said period, however, the permission is only in force until the day when the transplantation of plaice begins in the Limfjord. The gear may be used only E. of the line Odby Kirke—Rimmershuse (i.e. not in the western and central parts of Nissum Bredning. During the following years this gear was used to a very great extent for catching sprat and small herring, and since that time it is called a sprat seine.

The demand for small herring (waste fish) and sprat, however, still increased, and therefore a desire arose to have an even more intensely fishing gear like the sprat trawl used in the Belt Sea since 1936. A notification of Jan. 1st, 1940, then permitted sprat trawls of the same kind as those of the Belt Sea to be used in the Limfjord for catching small herring and sprat. It is conditioned that the seine must nowhere have a mesh-width of less than 13 mm[2]) from knot to knot. The necessary weights must be attached to the seines by means of straps, so that the fishing gear does not touch the bottom. The span of the seine along the head-line from one pole to the other must not exceed 19 m. It is prohibited to distend the gear by using two boats. Sprat trawls may be used between Nov. 1st and March 31st and throughout the Limfjord as far westwards as the line Odby Kirke—Rimmershuse in Nissum Bredning. The permission to use sprat seines and sprat trawls is provisional and must be renewed every year, which has taken place ever since its introduction.

---

[1]) Already during the reading of the Fisheries' Act of 1907 it was proposed to allow the use of a cod seine with a mesh-width of $1^1/_2$ Dan. inch; the proposal was not carried.

[1]) But only for one year at a time.

[2]) In 1946 altered to 14 mm, and at the same time the use of the gear was allowed from Oct. 1st. Since 1946 it is further prohibited from sprat trawls to land catches, in number containing more than 50 % of small herring, and totally prohibited to land sprat between April 15th and Sept. 30th. Through these alterations a more effective protection of small sprat and small herring is intended.

The sprat trawl represents a very intensely fishing gear for the catching of small herring and sprat (and to a less degree of larger herring); to-day the sprat and small herring fisheries are mainly practised with this gear, and both herring seines and sprat seines have grown comparatively insignificant as catching gears for small herring and sprat.

In other words the development in the Limfjord through the last three scores of years has been that the old herring seine—used for centuries—which was still the prevalent gear for the catching of both large herring and small herring and sprat as late as the beginning of the present century, has now generally speaking been replaced by two special gears, the herring pound-net for the catching of large herring and the sprat trawl for the catching of small herring and sprat.

Table 1. Numbers of herring seines, sprat seines and sprat trawls in the Limfjord in the year 1919—1944.

Year	Herring seines	Sprat seines	Sprat trawls
1919	67	134	..
1920	65	147	..
1921	62	172	..
1922	52	207	..
1923	50	205	..
1924	50	174	..
1925	51	147	..
1926	41	114	..
1927	34	103	..
1928	29	115	..
1929	6	122	..
1930	6	127	..
1931	9	130	..
1932	17	130	..
1933	15	130	..
1934	17	150	..
1935	11	163	..
1936	11	164	..
1937	5	136	..
1938	6	148	..
1939	9	140	..
1940	4	30	55
1941	4	30	50
1942	2	30	58
1943	4	30	50
1944	4	40	50

Quoting "Fiskeri-Beretningen" Table 1 gives the numbers of herring seines, sprat seines and sprat trawls in the Limfjord during the years 1919—1944. Before 1919 no cod seines are stated to exist in the Limfjord, but a small number of these gears must be supposed to have been used at any rate in 1918 since the gear was legalized already in 1917. In 1917, "Fiskeri-Beretningen" says, many cod were taken in cod seines, but already in 1923 large amounts of small herring are stated to be caught in this gear, and in 1925 the catches principally consisted of herring, small herring and sprat.

2. Catching localities.

Whether the herring seiners have been using herring seines, sprat seines or sprat trawls the catching grounds have been nearly the same, the comparatively deep parts, primarily the narrows of the Fjord: Sallingsund, Fursund, Hvalpsund, Virksund and Vilsund, further Thisted and Risgaarde Bredning and, as regards the herring seines of older times, also certain parts of the narrow Fjord E. of Løgstør.

The old fishing grounds for herring seines—shots or warping places—were protected against damages from other fishing gears by various regulations: it was, and incidentally is forbidden to place stake gears in the warping places used from old times, and also other stationary gears must give way to the herring seines here. For that reason the localities for herring seining were precisely defined. In the Fjord W. of Løgstør the principal warping places were found in the following localities[1]): in Sallingsund at Pinen and on the opposite side of the sound near Glyngøre; at Ørodde; in the narrow at Fur; several localities at Hvalpsund; in Thambosund at Jegindø; in Venøsund; in Vilsund; at Dragsbæk Vig and on the Mors side of Feggesund. E. of Løgstør warping places were found at Uttrup immediately E. of Aalborg, at Gjøl and at Egholm.

Generally a couple of herring seines were used simultaneously at the same warping place: while one of them was being emptied ashore, the other had been shot, and the men from the different seines then helped each other with the hard job of hauling.

Of course the Danish seine and board seine fisheries of to-day are not locally bound to the same extent as the herring seine fishery, but all the same they are mainly pursued within the same areas: Virksund, Hvalpsund, Risgaarde Bredning, Fursund, off Ørodde, throughout Sallingsund, in Kaas Bredning,

[1]) From Annex 44 to "Considerations of the Committee Appointed by the Ministry of Agriculture for the Revision of the Legislature on the Salt Water Fishery", Copenhagen 1903.

THISTED
LØGSTÖR
THY
Vil Sund
Livø-Bredn
FUR
NYKJÖBING
MORS
Visby-Bredn
Thyboron-Kanal
Nes-Sund
Salling-Sund
Risgaarde-Bredn.
LOVNS-BREDN.
Harre-Vig
Kaas-Bredning
SALLING
THYHOLM
SKIVE-FJORD
SKIVE
LEMVIG
VENÖ BUGT
STRUER
HJARBÆK-FJ.
Lodbjerg Fyr
Bovbjerg Fyr
Klitmoller
Aggersund
Frederik VII's Kanal
Livø Bredning
Nissum Bredning
Lavbjerg Bredning
Venö Bredning
Kaas-Hoved
Erholle-Hoved
Hjarbæk
Skive
Struer
Lemvig
Thyborøn
Agger
Kobberø
Vist
Tørring Sø
Nørre-Nissum
Sallingsund
Harre Nor
Bjørk Nor
Astrup-Vig
Sandsgaard-Vig
Virk-Sund
Jegindø
Tambo-Sø
Skibsted Fj.
Dragstrup Vig
Branden
Junget Ore
Hvalsund
Sund-ore
Grønning-Ore
Fjerslev Rønner
Blinde Rønner
Dranby Vig
Buxer-Odde
Sillerslev Ore
Lysen-Bredn
Sønderlem-Vig
Kilen
Tuskjær
Agger Tange
Thyborøn Tange
Langerhuse
Geller Odde
Dover Odde
Nees
Klosterup Vig
Lavbjerg Hage
Ronbjerg Hage
Sennels Hage
Fegge Klit
Bjerre Hage
Ræn Klit
Lyngsø
Torup
Stenbjerg
Lyngby
Orhage
Vorupør
Hvalpsund
Løkken
Ålbæk
Lundø
Ørsø
Ø. Vandet
Vandet
Flyngøre
Ertholle-Hoved
Jelse Odde
Kalkgrund
Kalkgrund Hage
Kalkgrund Rev
Kalkgrund Rønner
Kalkgrund Rønner
Kalkgrund Rønner

Lütken[1]) tells about the herring seines, which were then used extensively throughout the Fjord from Sallingsund to Hals, that about 1740 "large quantities of young herring were hauled ashore by the barrel and sold as food for swine at 4—6 Skilling per barrel", i. e. at a price of about $^1/_{10}$ Dan. Øre per kg.

Well into the nineties small herring and sprat, besides being used as food for swine, were only sold to be used as bait by the fishermen of the west coast for their cod and haddock hooks; also later on considerable quantities were sold for this purpose.

In "Fiskeri-Beretningen" for 1896 it is stated for the first time that large quantities of sprat were sold at high prices to the kippering industries of Eckernförde and Kiel. This possibility of export was turned to good account during the following years. Soon, however, enterprising men understood that we might just as well smoke the sprat ourselves, and already in 1898 smoke-houses had been built at Thisted (P. Taabel and Co.) and Struer (F. H. Mehlsen) where sprat were bought and sold as kippers both at home and abroad.

The possibilities of selling small herring were also improved as the years went: cold stores were established, so that the fishermen were no longer so dependent on the momentary call for bait. In spite of this, however, the prices in 1905 had risen no higher than about 2—3 Dan. Øre per kg of small herring and about 20 Øre per kg of sprat.

This rise of the possibilities of sale carried with it an increasing importance of the catch yields of small herring and sprat, and so a desire arose to make the herring seine more suitable for the catching of these very fishes. The Fisheries' Act of 1907 therefore—as mentioned above—introduced the regulation that between Oct. 15th and March 31st the outmost $7^3/_4$ m of the bag might have a mesh-width of only 12 mm as against the 15 mm from knot to knot stipulated in the Fisheries' Act of 1888. About the same time new markets for the small herring opened because the pond farms of Jutland now began to use small herring as fodder for the pond trout. The seine catches of sprat had gradually risen to a considerable height, and between 1907 and 1911 it is often mentioned in "Fiskeri-Beretningen" that sprat constituted the greater part of the herring seine catches; for 1912 it is stated that sprat amounted to $^1/_5$ of the total yield of the herring fishery of the Limfjord.

For several years between the two great wars considerable quantities of small herring were exported from the Limfjord to Norway where they were used in the canning factories. This export was of special importance at the middle of the twenties when the Norwegian fishery could not find sufficient quantities of small herring for industrial purposes. The fish were sent by special steamer directly from the Limfjord to Norway. During recent years the principal purchasers of the small herring are the pond farms and the fish meal factories, and only a very small portion of the catches of small herring are used as bait. Most of the sprat are sold in this country where they are used in the canning industry or go to the smoke-houses. A small portion of the sprat is exported in a fresh state. Only the larger sprat go to the smoke-houses or are used in other ways as human food; the small sprat are sold together with the small herring as waste fish; in sorting the fish 8 cm is put as the limit between larger and smaller sprat.

Before 1921 the yields of the small herring and sprat fisheries were not put down separately in the fishery statistics but included in the herring fishery. Though, accordingly, no definite figures for the yields of small herring-sprat fisheries of this period can be given, we know that they have been very considerable at any rate in certain years when they made up at least 20 % of the weight landed by the whole herring fishery. The yields of the small herring and sprat fishery during the years after 1921 are given in Table 2. The yield of the small herring fishery varied highly between 1921 and 1944, now being very high, now very low though no definite rise or fall is observable for the whole period. The lightest yield occurred in 1940 with only 20 tons, the heaviest in 1923 with 1600 tons. It must be noted that the catch figures for small herring for the years 1921—42 also include sprat below the marketable size (about 8 cm) and other waste fishes (for instance sea scorpion, etc.), but from 1943 the figures represent small herring alone. However, the difference between the two statements is not very great: for 1943 the catch of small herring is put at 818 tons, that of other waste fishes at 80 tons only.

Also the price per kg of small herring varied highly, in the years between the two great wars between 1

[1]) Chr. Lütken: Survey of the activities and negotiations of earlier fishery committees. Tidsskr. for Fiskeri, Ny Række, Bd. 3, 1876—77.

Table 2. Yields of the herring, small herring and sprat fisheries in the Limfjord during the years 1921—44.

(From "Fiskeriberetningen".)

Year	Herring		Small Herring		Sprat	
	Tons	1000 Kr.	Tons	1000 Kr.[1])	Tons	1000 Kr.
1921....	3 367	926	42	8	26	16
1922....	1 751	416	237	12	41	16
1923....	3 086	644	1 600	158	76	23
1924....	3 204	729	443	22	100	50
1925....	3 365	908	800	32	259	65
1926....	1 358	451	399	19	309	80
1927....	1 562	475	390	12	820	149
1928....	975	416	926	37	446	67
1929....	582	180	400	12	369	75
1930....	534	174	1 051	20	380	114
1931....	1 087	226	860	15	435	70
1932....	757	123	740	12	500	50
1933....	462	113	701	11	496	61
1934....	427	103	172	3	313	37
1935....	371	110	160	1	582	55
1936....	562	167	311	16	520	35
1937....	321	112	242	5	165	29
1938....	230	79	620	14	219	45
1939....	1 650	367	191	5	842	90
1940....	739	205	20	1	845	164
1941....	1 145	569	291	37	638	157
1942....	347	205	841	150	120	50
1943....	1 061	623	818[2])	99	327	86
1944....	542	377	776	96	50	22
1945....	450	..	1 500	100	190	85

[1]) The values of the small herring and sprat fishery in the years 1921—29 from A. C. Johansen, 1929.

[2]) The figures for small herring down to 1942 incl. cover both small herring, small sprat and other waste fishes; from 1943 they include small herring alone.

and 5 Øre; it was comparatively high, 4—5 Øre, during the years of the twenties in which there was a considerable export of small herring to Norway; the price was particularly low at the beginning of the thirties. During the second world war the price—like all other prices—rose very much, from 2.6 Øre in 1939 to 18 Øre in 1942; in 1943 there was another fall to 13 Øre. In the poorest years the yields valued only about 1000 Dan. Kr., in the best years they rose about 150 000 Kr. In comparison it may be mentioned that the value of the proper herring fishery during the same period ranged between 80 000 and 900 000 Kr.

The catch figures allow no conclusions on a connexion between the yields of the herring fishery and the small herring fishery. There would be reasons to expect that heavy catches of herring would be landed 1 or 2 years after heavy catches of small herring. It is true that such a connexion can be traced in certain years, but in other years it cannot be found. Neither is a good herring year followed by large catches of small herring 1 or 2 years later (when the fry have reached this stage of development). There may be two causes of the lack of such a connexion: i. the season of the small herring fishery falls within the months of November—March and consequently affects two years of the fishery statistics, which always follow the year of the calendar; ii., and this is no doubt the primary cause, a considerable part of the small herring do not belong to the herring races that spawn in the Fjord and are caught here as grown-up fish, but enter the Fjord from without and emigrate again before they reach the adult stage (see further p. 20).

Also the yield of the sprat fishery shows great annual variations though not to the same extent as the small herring fishery. In the poorest years between 1921 and 1944 about 20—40 tons of sprat were landed, in the best years 800—850 tons, but also the sprat fishery shows no steady rise or fall of the yield during the whole series of years, good and poor catch years occurring both at the beginning and towards the end of the period though recent years generally speaking show somewhat heavier catches. The catch yield ranges between 15000 and 160000 Kr. and is mostly a good deal higher than that of the small herring fishery. In the years 1932—39 when the price of small herring ranged between 0.9 and 3.5 Øre per kg, the price of sprat was 7—20 Øre per kg or about 6 times higher. During the last war the price rose to 40 Øre per kg.

4. On the quantities of the different fishes and their sizes in catches from sprat seines and sprat trawls and on the influence of the fishery with these gears on the fish population of the Limfjord.

The use of such fine-meshed gears as sprat seines and sprat trawls of course involves the possibility that considerable quantities of the youngs of commercial fishes are removed, so that the stock of them is reduced to such a degree that it influences the fishery. The investigations carried out by the Biological Station for a series of years in order to find out whether the use of these gears involves a danger to the fish population included partly a determination of the weight ratios of the different fishes of the catches, partly measurings of the individual specimens.

Table 3. Weight percentages of different fishes and bottor

Sample No.	1	2	3	4	1—4	
Date	9/11 1935	9/12 1935	10/1 1936	4/3 1936	1935/36	
Locality	Off Ørodde	Hvalp-sund	Thisted Bredn.	Thisted Bredn.	All samples grammes	%
Herring	21.3	21.4	5.7	22.5	13 210	16.7
Sprat	14.1	76.7	92.2	77.5	48 890	61.7
Anchovy	..	..	..	..	..	..
Mackerel	..	..	..	..	..	..
Cod	11.3	..	..	..	2 800	3.5
Whiting	49.4	..	..	..	12 300	15.5
Flounder	..	..	..	..	..	..
Plaice	..	..	..	..	..	..
Sea scorpion	1.6	..	..	..	400	0.5
Viviparous blenny	2.0	1.5	1.7	..	1 300	1.7
Freckled goby	0.4	0.2	0.1	..	175	0.2
Threespined stickleback	..	..	..	..	..	..
Mussels	..	..	..	..	..	..
Whelk *(Buccinum)*	..	..	..	..	..	..
Dog-whelk *(Nassa)*	..	..	..	..	..	..
Shrimp	..	0.2	0.2	..	100	0.1
Brittle star	..	..	0.1	..	25	0.0
Actiniae	..	..	..	..	..	..
Ascidiae	..	..	..	..	..	..
Sea-weed and shells	..	..	..	..	..	..
Weight in grammes of the sample examined	24 900	26 400	23 900	4 000	79 200	..

Table 4. Weight percentages of different fishes and bottor

Sample No.	13	14	15	16	17	18	13—18		19	20	21	22	23	19—23		24	25
Date	9/11 1940	9/11 1940	19/11 1940	20/11 1940	10/12 1940	10/12 1940	1940/41		21/11 1941	3/12 1941	3/12 1941	16/12 1941	18/12 1941	1941/42		25/11 1942	25/11 194
Locality	Kaas Bredn.	Salling-sund	Risgrd. Bredn,	Risgrd. Bredn.	Salling-sund	Kaas Bredn.	All samples grammes	weight %	Thisted Bredn.	Fur Havn	Risgrd. Bredn.	Thisted Bredn.	Nissum Bredn.	All samples grammes	weight %	Salling-sund	Fur sund
Herring	28.8	34.5	29.3	6.3	63.3	70.0	7 600	38.0	74.2	3.1	5.0	68.3	64.2	16 950	32.6	93.0	91.
Sprat	65.5	60.0	68.3	77.7	34.0	26.0	11 180	55.9	25.8	94.5	94.3	31.1	19.6	33 660	64.8	5.8	8.
Anchovy	..	..	..	0.2	..	..	5	0.03	..	..	..	..	..	..	..	..	..
Mackerel	..	..	..	0.3	..	..	10	0.05	..	..	..	..	..	..	..	..	..
Cod	..	..	..	..	..	..	..		..	..	..	0.3	..	50	0.1	..	..
Whiting	6.3	5.5	..	..	2.7	4.0	670	3.4	..	..	..	..	0.8	40	0.1	1.3	..
Flounder	..	..	..	5.3	..	..	160	0.8	..	..	..	..	..	..	..	..	..
Plaice	..	..	..	..	..	..	..	..	..	..	..	..	0.2	10	0.02	..	..
Sea scorpion	..	..	..	6.0	..	..	180	0.9	..	0.8	..	..	10.9	660	1.1	..	..
Viviparous blenny	..	..	..	..	..	..	..	..	..	0.1	..	..	2.6	150	0.3	..	..
Freckled goby	..	..	0.3	..	..	..	10	0.05	..	1.4	0.7	0.3	..	350	0.7	..	.
Threespined stickleback	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mussels	..	..	2.0	4.2	..	..	185	0.9	..	..	..	..	..	..	..	..	..
Whelk *(Buccinum)*	..	..	..	..	..	..	..	..	..	..	..	..	0.4	20	0.04	..	..
Dog-whelk *(Nassa)*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Shrimp	..	..	..	..	..	..	..	..	..	..	..	..	0.2	10	0.02	..	..
Brittle star	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Actiniae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ascidiae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sea-weed and shalls	..	..	..	..	..	..	..	..	..	..	..	..	1.0	50	0.1	..	..
Various	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Weight in grammes of the sample examined	4 000	4 000	3 000	3 000	3 000	3 000	20 000	..	3 100	14800	14000	15100	4 950	51 950	..	4 000	3 83

[1]) In the sample further 30 g of smelt. [2]) Incl. 0.2 % of long-spined bullhead. [3]) In the sample further 8 g of smelt.

imals in catches with sprat seines in the Limfjord.

5	6	7	8	5—8		9	10	11	12	9—12		1—12	
5/1 1939	5/1 1939	24/1 1939	24/1 1939	1938/39		23/11 1939	23/11 1939	27/12 1939	30/12 1939	1939/40		1935/40	
isgaarde Bredn.	Hvalp-sund	Virk-sund	Lovns Bredn.	All samples grammes	%	Hvalp-sund	Virk-sund	Thisted Havn	Thisted Bredn.	All samples grammes	%	Total grammes	%
21.4	15.0	16.2	28.6	6 535	20.9	3.8	2.0	..	..	230	1.3	19 975	16.9
78.2	85.0	81.7	71.0	24 450	78.3	95.8	97.3	100.0	100.0	17 710	98.5	81 050	68.5
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	2 800	2.4
0.4	..	..	..	50	0.2	..	..	..	..	..	..	12 350	10.4
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	2.1	..	160	0.5	..	..	..	..	..	..	560	0.5
..	..	..	..	..	..	..	..	..	..	..	..	1 300	1.1
..	..	..	..	..	..	..	..	..	..	..	..	175	0.1
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	0.5	0.8	..	..	50	0.3	150	0.1
..	..	..	..	..	..	..	..	..	..	..	..	25	0.02
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	0.4	20	0.1	..	..	..	..	..	..	20	0.02
16 350	2 000	7 585	5 280	31 215	..	4 000	4 000	3 700	6 290	17 990	..	118 405	..

imals in catches with sprat trawls in the Limfjord.

26	27	24—27		28	29	30	31	32	33	28—33		34	35	36	37	34—37		13—37	
5/12 942	9/12 1942	1942/43		9/11 1943	23/11 1943	27/11 1943	7/12 1943	5/1 1944	14/2 1944	1943/44		21/11 1944	11/1 1945	11/1 1945	15/2 1945	1944/45		1940/45	
isted redn.	Salling-sund	All samples grammes	weight %	Fur-sund	Salling-sund	Struer Vig	Risgrd. Bredn.	Thisted Bredn.	Salling-sund	All samples grammes	weight %	Salling-sund	Salling-sund[1])	Thisted Bredn.	Hvalp-sund[3])	All samples grammes	weight %	Total grammes	weight %
3.8	38.3	17 670	54.5	96.0	85.0	94.1	99.3	51.3	94.7	58 500	91.7	75.0	24.0	79.0	19.5	10 170	32.2	110 890	55.5
5.0	59.2	14 160	43.7	3.6	12.8	4.0	0.7	48.8	4.9	4 580	7.2	24.5	46.0	21.0	72.6	13 740	43.5	77 320	38.7
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	+
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	+
..	0.2	50	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100	0.05
..	0,1	70	0.2	..	..	..	..	..	..	..	..	0.3	0.08	..	..	10	0.03	790	0.4
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	160	0.08
..	0.5	100	0.3	0.4	..	..	..	..	..	90	0.1	..	..	..	..	..	..	200	0.1
..	..	..	..	..	..	..	..	..	..	..	..	..	12.4[2])	..	5.7	3 150	10.0	3 990	2.0
..	0.9	200	0.6	..	0.5	1.2	..	..	..	320	0.5	..	8.6	..	0.2	2 220	7.1	2 890	1.4
0.8	0.1	50	0.2	..	..	0.4	..	..	..	100	0.2	0.2	..	..	0.8	35	0.1	545	0.3
..	..	..	..	..	..	0.1	..	..	..	15	0.02	..	..	..	0.2	5	0.02	20	0.01
0.3	..	10	0.03	..	0.8	..	..	..	..	30	0.05	..	0.1	..	..	30	0.1	255	0.1
..	..	..	..	..	..	0.1	..	..	..	20	0.03	..	0.3	..	..	70	0.2	110	0.06
..	..	..	..	..	..	0.1	..	..	..	15	0.02	..	..	..	..	..	..	15	+
0.3	0.1	20	0.06	..	0.3	0.1	..	..	..	60	0.1	..	..	..	0,8	10	0.03	100	0.05
..	..	..	..	..	..	..	..	..	..	..	..	..	0.02	..	..	5	0.02	5	+
..	0,5	100	0.3	..	0.3	..	..	..	0.2	20	0.03	..	0.8	..	..	200	0.6	320	0.2
..	..	..	..	..	0.5	..	..	..	..	20	0.03	..	5.9	..	..	1 500	4.8	1 520	0.8
..	..	..	..	..	..	..	..	..	..	..	..	..	1.3	..	..	340	1.1	390	0.2
..	..	..	..	..	..	..	..	..	..	..	..	..	0.3	..	..	65	0.2	65	0.03
000	20 600	32 430	..	25 000	4 000	25 250	1 510	4 000	4 010	63 770	..	3 000	25 400	2 000	1 150	31 550	..	199 700	..

For each of the samples examined Tables 3 and 4 give the weight percentages of the different fishes and bottom animals from sprat seines and sprat trawls, respectively. Fig. 2 shows the percentile weight amounts of various species of fish taken in the two gears.

In the sprat seine (see Fig. 2), which was used in the years 1935—40, sprat and small herring together

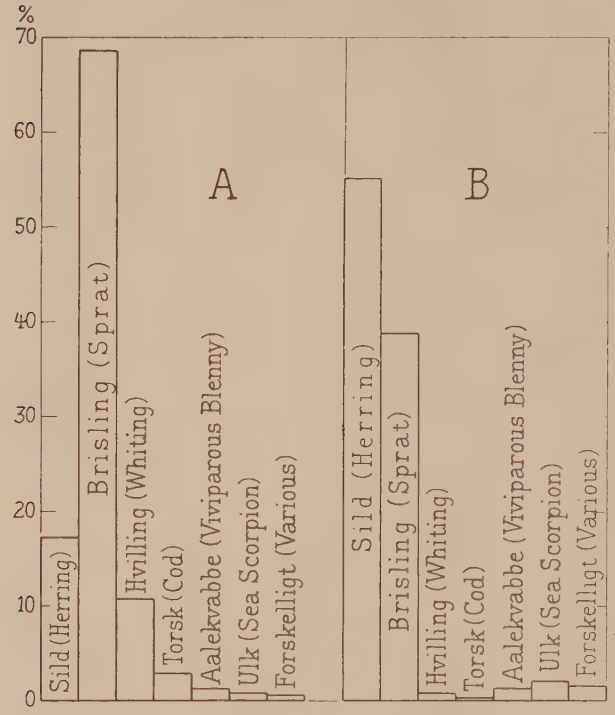


Fig. 2. Percentile weight amounts of the different species of fish (and invertebrate bottom animals) taken in sprat seines, 1935—39 (A) and sprat trawls, 1940—44 (B) in the Limfjord.

constituted 85 % of the catches, in other words by far the greater part. Of these two species the sprat predominated, making up 68.5 % of the weight as against 16.9 % of the small herring. In succession follow whiting with 10.4 %, cod with 2.4 %, viviparous blenny with 1.1 % and sea scorpion with 0.5 %. The group "Various" includes freckled goby (0.1 %), shrimp (0.1 %) and brittle star, sea-weed and shells with 0.02 % each.

In the sprat trawl (Table 4 and Fig. 2), which is used after 1940, sprat + small herring constituted no less than 94 weight %s of the catches or even more than in the sprat seine. Sprat alone made up 39 % or much less than in the sprat seine while small herring cover 55 % or more than 3 times as much as in the sprat seine. Next follow sea scorpion with 2 % and viviparous blenny with 1.4 %. Cod and whiting reached only 0.05 and 0.4 %, respectively. All other fishes together represent only 0.5 %, various invertebrates, shells, etc. 1.4 %.

In other words these two gears yield very pure catches of sprat and small herring, and in the great majority of analyses the catches of other fishes are quite insignificant. Of the 318 kg of fish (+ invertebrate bottom animals) examined in the course of years from these two gears small herring and sprat constituted 289 kg or 91 %. Only one analysis (No. 1) from the sprat seine on 25.XI.1935 showed considerable amounts of other fishes: 49 % of whiting and 11 % of cod. None of the other 36 analyses showed higher percentages than 11 of other species than sprat and small herring. Accordingly, no great damage can be done to other stocks of fish during this fishery.

In 1942—43 the sprat seine and sprat trawl fisheries (particularly the latter) gave about 1000 tons of fish a year in the Limfjord. A calculation on the basis of the analyses from 1935—45 gives the following amounts of the different species of fish in these 1000 tons:

	Weight % in the analyses	Weight amount in the catch yield (1000 tons)
Sprat	50.0	500 tons
Small herring	41.0	410 -
Whiting	4.0	40 -
Sea scorpion	1.4	14 -
Viviparous blenny	1.3	13 -
Cod	0.9	9 -
Freckled goby	0.2	2 -
Plaice	0.1	1 -
Flounder	0.05	0.5 -
Others	1.0	10 -

The group "Others" includes anchovy (with 50 kg), mackerel (with 100 kg) and stickleback (with 180 kg), a total of 0.3 ton; 0.7 ton consists of invertebrates + shells. Among the species mentioned here beside small herring and sprat only viviparous blenny, cod, plaice, flounder and mackerel are important fishing objects. The sea scorpion is nothing but a noxious animal, and the more individuals of this species are destroyed by the waste fish fishery, the better for the commercial fishes.

We will now try to find out whether the removal of the said species of commercial fishes may be supposed to damage the fish population. The viviparous

Table 5. Lengths in cm of fishes (minus small herring and sprat) taken in sprat seines in the Limfjord between 1935 and 1939.

(Analyses No. 1—12.)

	Whiting	Cod	Sea scorpion	Viviparous blenny
8 cm	..	..	1	..
9 -	..	1	1	..
10 -	7	..	..	1
11 -	20	2	..	4
12 -	41	3	..	3
13 -	52	3	..	2
14 -	34	8	..	2
15 -	22	9	..	2
16 -	15	8	..	3
17 -	7	12	..	..
18 -	4	4	..	..
19 -	2	5	3	..
20 -	5	3	1	..
21 -	1	3	1	..
22 -	..	1	..	..
23 -	1	..	1	..
Total	211	62	8	17
Mean length in cm	13.6	16.1	17.3	13.1
Grammes	3550	2800	910	350
Grammes/1 ind.	16.8	45.2	113.8	20.6

blenny taken in the seines have (Tables 5 and 6) a length of 10—26 cm, averaging about 20 cm; specimens of this size can very well be used for bait or human food, and so no harm is done if they are taken in the seines.

The catch of cod is calculated to total 9 tons a year; the cod taken vary in length between 9 and 22 cm, averaging 16 cm. As the fishery takes place during the winter season, these cod must have been hatched during the previous spring, thus being youngs of about $^3/_4$ year. The amount of young cod in the Limfjord is subject to very great annual variations[1]). During the winters from which analyses of catches from sprat seines and sprat trawls are in hand the stock of cod fry, as shown by other investigations, was comparatively large only in 1935/36 and 1938/39, and large amounts of young cod may therefore be supposed to occur only in the catches of these winters. Large amounts of young cod were indeed taken in the winter of 1935/36, but not in

[1]) H. Blegvad: Quantitative Investigations of Bottom Invertebrates in the Limfjord 1910—27 with Special Reference to the Plaice Food. Rep. Dan. Biol. St., XXXIV, 1928.

Table 6. Length in cm of fishes (minus small herring and sprat) taken in sprat trawls in the Limfjord between 1940 and 1945.

(Analyses No. 13—37.)

	Whiting	Cod	Sea scorpion	Viviparous blenny	Plaice	Flounder	Smelt	Mackerel	Anchovy
6 cm	1	..	..	..	..	..	..	..	..
7 -	1	..	..	..	1	..	7	..	..
8 -	1	..	..	..	..	..	3	..	..
9 -	5	..	..	..	..	..	1	..	1
10 -	6	..	..	..	..	..	..	..	..
11 -	4	..	1	1	..	..	..	..	..
12 -	6	..	..	2	..	..	..	1	..
13 -	5	..	1	2	..	..	..	..	..
14 -	4	1	..	1	..	..	..	..	..
15 -	2	..	1	1	1	..	..	..	..
16 -	1	..	..	1	..	..	..	..	..
17 -	..	1	2	1	1	..	..	..	..
18 -	1	..	2	1	1	..	..	..	..
19 -	2	..	3	1	..	..	..	..	..
20 -	..	..	6	2	..	..	..	..	..
21 -	..	..	2	3	..	..	..	..	..
22 -	..	..	3	3	..	..	..	..	..
23 -	..	..	4	8	..	..	..	..	..
24 -	1	..	2	4	..	1	..	..	..
25 -	..	..	4	4		..	..	..	..
26 -	..	..	1	2	..	..	..	..	..
Total	40	2	32	37	4	1	11	1	1
Mean length in cm	12.2	15.5	20.7	20.6	13.2	24.0	7.5	12.0	9.0
Grammes	930	100	5535	2517	150	160	30	10	5
Grammes/1 ind.	23.3	50.0	173.0	68.0	37.5	160.0	2.7	10.0	5.0

any other of the winters, not even in the winter of 1938/39 when they might be expected to appear. In the winter of 1935/36 the young cod made up 3.5 weight per cents of the examined catches from sprat seines (trawls were not yet in use). With a catch of about 1000 tons—the average figure of recent years—this percentage will mean the catching of about 35 tons of small cod or about 800 000 individuals. This great wastage of the amount of youngs will no doubt be perceptible in the cod fishery though it cannot be said to be devastating to the cod population. Of course it is difficult to say how great a loss in tons the fishery will suffer if about 800 000 youngs are spoiled every year, but we are able to estimate the figure. Naturally only a fraction of the 800 000 individuals will grow up to become market fish, and of these again only a certain part will be caught. The fishing experiments of the Biological Station with the eel seine in our inner waters have shown[1]) that this gear takes half as many cod of $1^1/_2$ as of $^1/_2$ year and again half as many of $2^1/_2$ years as of $1^1/_2$. These figures mean that 200 000 of the 800 000 pieces of fry will reach an age of $2^1/_2$ years or a weight of about 300 tons. Marking experiments in various Danish waters including the Limfjord have shown that about $^1/_3$ of these cod or about 100 tons will be captured. In the good years among these twenty years the Limfjord yielded about 200—250 tons of fish, and so it is obvious that the removal of 800 000 youngs may influence the fishery to a rather considerable degree. The years, however, in which the seine fishery spoils so large amounts of youngs are very few; in most years the figure must be put much lower (about 80 000 pieces of youngs). On the whole the destruction can therefore hardly be of such an extent that it justifies a restriction of the seine fishery, but it is sufficiently great to call the seiners' attention to the necessity of limiting the destruction of the young cod as much as possible. This may be attained either by liberating the largest possible number of the young cod in a viable state or—and perhaps particularly—by stopping the seine fishing in localities where large quantities of small cod are observed in the seines.

[1]) Erik M. Poulsen: On the Cod Population of the Limfjord. In Danish. Publ. by Komm. f. Danmarks Fiskeri- og Havundersøgelser, No. 11, 1942.

Erik M. Poulsen: On Fluctuations in the Size of the Stock of Cod in the Waters within the Skaw during Recent Years. Rep. Dan. Biol. St., XLVI, 1944.

Plaice are rare in the seine catches. Out of the average catch of 1000 tons of fish in the seines only 1 ton—according to the calculation—consists of plaice. The few plaice (a total of 4) seen in the catches examined had a length of 7—18 cm, all of them thus being below the minimum size limit. Their mean weight was 38 g, so that 1 ton of plaice from the seines corresponds to 30 000 individuals. This figure is not high. During the years before the war about 1.5 mill. young plaice were transplanted annually to the inner broads of the Limfjord; accordingly, the amount of young plaice removed corresponds to only $^1/_{50}$ of the youngs transplanted per annum. So it is obvious that this seine fishery cannot perceptibly damage the plaice population of the Fjord.

The next commercial fish in the series of fishes taken in the seines is the flounder. The calculations say that about 1 ton, or the same amount as of plaice are taken annually. Against about 100 tons of flounder caught annually in the Limfjord the catching of 1 ton in the seines is of very small importance. The catches of mackerel in the seines is quite insignificant.

These investigations seem to show that there is no reason for the fear that the sprat seine and sprat trawl fishing for small herring and sprat will perceptibly damage the stocks of other commercial fishes, with the exception of the cod population in quite a few years only. But the question remains whether the stocks of herring and sprat themselves are damaged to any considerable degree by this fishery.

As mentioned above the yield of the sprat fishery is most variable. In 1920—21 it was about 25 tons, at the beginning of the thirties about 500 tons and in 1939—40 even 800 tons; generally speaking there is in other words a considerable rise of the yield during these years. But during recent years the yield fell rapidly: in 1942 it was only 120 tons, in 1943 327 tons, in 1944 even as low as 50 tons. It is a tempting conclusion that this fall of the latest years is the consequence of a too intense fishing during the years immediately before. It should be remembered, however, that the years 1940—44 in several respects were so far from being normal, that other factors than the intensity of the fishery may have caused the decline of the yields.

Within this period we have firstly had the 3 severe ice winters of 1940—42. The sprat cannot endure severe cold and ice; during earlier severe ice winters

large quantities of dead sprat have often been observed[1]); they had either drifted ashore or were frozen up in the ice. Also in the ice winters of 1940—42 large quantities of dead (from cold) sprat were observed in the Limfjord; in several cases they were so numerous, that they were "fished for": the dead sprat were taken in catchers when floating at the surface or whole frozen lumps of them were cut out of the ice. It is reported that one person in this way could "fish" about 40 kg of sprat per day with his axe. It is beyond doubt that large amounts of sprat died during these 3 ice winters, and the rapid decrease of the sprat population of the Limfjord during recent years (1942—43) may very well be due to the increased mortality during the ice winters.

The continued rapid decrease after 1943—44 need not either be caused by a too intense fishing; it may also be due to the fact that the sprat fishery of 1944 was pursued with less than the usual intensity, partly on account of the difficulties in providing oil, partly because a considerable part of the fishing fleet was engaged in mussel fishery.

The decrease of the sprat population of the Limfjord during recent years appears not only from the falling catch yields but also from a calculation of the amount of sprat as compared to the amount of small herring (and other fishes) in the examined samples from the sprat seine catches. Fig. 3 is a graphical representation of the weight percentages of sprat and small herring in the samples of the different years. It is seen that in the winter of 1938/39 the sprat made up 78 % and in the winter of 1939/40 (all samples were taken in November-December before the beginning of the ice period) even 98 % of the catches. In the two following years—after the first and second ice winter—the weight percentage of sprat sank to 60 % and in 1942/43—after the third ice winter— to 44 %. Next year, 1943/44, there was even a steeper fall of the weight percentage to only 7 %. It is true that 1943/44 was no ice winter, but the consequences of the previous ice winters will of course last on till the stock has recovered by the hatching and growing-up of the new fry, which will take at any rate 1 or 2 years, perhaps even more on account of the pronounced deterioration of the stock of mother fish. The decrease to only 7 % in 1943/44 is undoubtedly a consequence of the ice winters. In 1944/45 the weight percentage rose somewhat, to 39 %. The stock is apparently recovering now from the effects of the ice winters.

Accordingly, both the fishery statistics and the examinations of the catches carried out by the Biological Station show that there has been a marked decrease of the sprat population of the Limfjord during recent years. This reduction follows immediately on some years with heavy catches of sprat

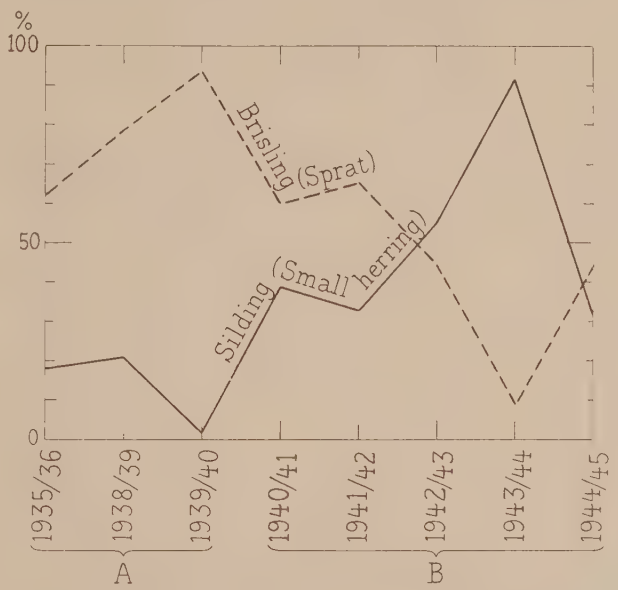


Fig. 3. Weight percentages of herring and sprat in samples from the individual years; sprat seine, A, (1935—36, 1938—39, 1939—40), sprat trawl, B, (1940—41, 1941—42, 1942—43, 1943—44, 1944—45).

and occurs simultaneously with 3 very severe ice winters, during which large quantities of sprat have died from cold. The ice winters undoubtedly have their great share in the decrease of yields, but it cannot at present be decided whether they are the only deteriorating factor or whether the intensity of the sprat fishery is also implicated. It is only a continuation of the investigations for some years more that can answer the important question whether or not the sprat population can endure the intense seine fishing of to-day.

Another problem connected with the sprat population *versus* the fishery is this: are the sprat caught at such a size and age, that they are utilized to the full by the fishery, or in other words: are too many small sprat taken in the seine fishery?

Tables 7 and 8 give the lengths of sprat taken in sprat seines and sprat trawls. The tables show that

[1]) A. C. Johansen: Mortality among Porpoises, Fish and the Larger Crustaceans in the Waters around Denmark in Severe Winters. Rep. Dan. Biol. St., XXXV, 1929.

sprat caught in the sprat seine have a mean length of 9.7 cm, those taken in the sprat trawl a mean length of 8.6 cm or about 1 cm less. For the individual years in which these gears were used the mean lengths of sprat were as follows:

Sprat seine	1935—36	10.6 cm	(527 ind.s)
—	1938—39	8.4 -	(1428 -)
—	1939—40	10.8 -	(1248 -)
Sprat trawl	1940—41	8.8 -	(1749 -)
—	1941—42	8.9 -	(551 -)
—	1942—43	8.6 -	(449 -)
—	1943—44	9.1 -	(484 -)
—	1944—45	7.6 -	(759 -)

In two of the three years in which the seine was used the mean length of the sprat was greater than in any of the years in which the trawl was used.

The mean of the trawl sprat is 1.1 cm lower than that of the seine sprat. This is remarkable inasmuch as the minimum mesh-width of the trawl is greater (13 mm) than that of the seine (only 10 mm). Therefore it can hardly be the different mesh-widths of the two gears that induce the different size of the sprat. The possibility cannot perhaps be overlooked that the stock of the years before 1940 mainly consisted of somewhat larger individuals than in later years. Through a reduction of the quantity of food animals of the sprat (the smaller plankton animals) the ice winters may have brought with them poorer conditions of growth for the sprat. It is hardly possible, however, to make a direct comparison between mesh-widths of seines and trawls because the actual mesh-width—the mesh-width during the

Table 7. Lengths in cm of sprat caught in sprat seines in the Limfjord.

Sample No.	1	4	1—4 1935/36	5	6	7	8	5—8 1933/39	9	10	11	12	9—12 1939/40	1—12 All samples
6 cm	..	..	..	10	1	1	..	12	..	1	..	..	1	13
7 -	..	..	..	120	41	31	16	208	..	..	..	1	1	209
8 -	1	..	1	298	217	106	107	728	1	..	6	10	17	746
9 -	5	6	11	24	56	95	78	253	13	39	6	10	68	332
10 -	75	161	236	10	39	73	46	168	81	140	23	26	270	674
11 -	81	175	256	2	12	22	17	53	181	148	130	137	596	905
12 -	3	17	20	1	1	..	4	6	40	23	102	119	284	310
13 -	2	1	3	..	..	..	..	..	1	..	3	7	11	14
Total	167	360	527	465	367	328	268	1 428	317	351	270	310	1 248	3 203
Mean lenght in cm	10.5	10.6	10.6	7.8	8.4	8.8	8.8	8.4	10.4	10.4	11.2	11.2	10.8	9.7
Grammes	..	3 100	..	1 570	1 700	1 700	1 500	6 470	3 830	3 890	3 700	4 490	15910	
Grammes/1 ind.	..	6.6	8.6[1]	3.4	4.6	5.2	5.6	4.5	12.1	11.1	13.7	14.5	12.7	8.4[1]

[1]) Sample No. 1 not included.

Table 8. Lengths in cm of sprat caug

Sample No.	13	14	15	16	17	18	13—18 1940/41	19	20	21	22	23	19—2 1942/4
4 cm	..	..	..	..	..	..	..	..	..	..	..	..	..
5 -	..	1	4	1	..	..	6	..	..	..	..	..	..
6 -	..	2	140	2	5	2	151	1	3	6	12	..	22
7 -	6	31	296	10	36	14	393	3	4	20	47	..	74
8 -	37	55	112	4	36	11	255	1	32	45	6	19	103
9 -	17	11	44	45	22	10	149	3	52	33	23	41	152
10 -	125	85	24	125	47	29	435	38	13	9	76	19	155
11 -	82	89	8	69	25	29	302	14	4	1	9	..	28
12 -	19	19	..	10	6	2	56	10	..	..	3	..	13
13 -	1	..	..	..	..	..	1	2	..	..	2	..	4
14 -	..	..	..	..	..	..	..	..	..	..	..	..	..
15 -	..	..	..	..	..	1	1	..	..	..	..	..	..
Total	287	293	628	266	177	98	1 749	72	108	114	178	79	551
Mean length in cm	10.7	9.7	7.2	10.0	8.9	9.6	8.8	10.3	8.7	8.2	8.9	9.0	8
Grammes	2 600	2 400	2 050	2 330	1 020	780	11 180	800	660	490	1 250	500	3 700
Grammes/1 Ind.	9.1	8.2	3.3	8.8	5.8	7.9	6.4	11.1	6.1	4.3	7.0	6.3	6
k	0.75	0.90	0.88	0.88	0.82	0.87	0.94	1.03	0.93	0.78	..	..	..

very catching—depends on the gear being only hauled up to an anchored boat or being dragged after a sailing boat for some time. The smaller length of the sprat from the trawl—in spite of its larger mesh-width—might be due to the fact that the meshes of the trawl are contracted comparatively more during the fishing than those of the seine.

The lengths of the sprat of all samples from both seine and trawl appear from Fig. 4. The smallest individuals are 4, the largest 15 cm long. Of the lengths 4, 5, 13, 14 and 15 cm there are very few individuals, 51 in all, of 6 and 12 cm there are comparatively few, 73 in all; the great majority, 6 410 individuals of a total of 7 195 individuals measured fall within the lengths 7—11 cm. It further appears from the figure that the individuals measured fall distinctly into two size-groups, one with a top at 7—8 cm and another with a top at 10—11 cm. This two-topped graph shows that the sprat caught mainly belong to 2 successive age-groups; one or two of the smallest individuals possibly belong to a still younger age-group, and among the 12—15 cm long individuals there are of course some of a still older age-group. The individuals of the smaller of these two size-groups (7—8 cm) are hardly of any great market value; when head and tail are deducted, there remains a body length of only 4 or 5 cm. In fact most sprat of 8 cm or less are sold together with the small herring as waste fish. Their low value also appears distinctly from a comparison between analyses No. 4 and 5 from the seine. The sprat of No. 4 have a mean length of 10.6 cm and nearly exclusively belong to the longer of the two groups; these sprat have a mean weight of 8.6 g. The sprat of No. 5, however, have a mean length of only 7.8 cm and belong to the shorter group; their mean weight is only 3.6 g or less than half the weight of the one year older sprat of the other size-group.

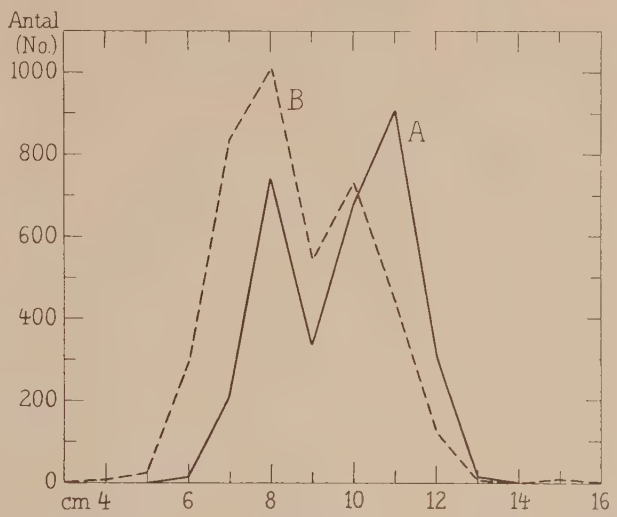


Fig. 4. Lengths of sprat from sprat seines (A) and sprat trawls (B).

A contemplation of the individual analyses of the tables shows us that we only in rare cases have such catches consisting nearly exclusively of one of the two size-groups; in most cases both groups are

sprat trawls in the Limfjord.

24	25	26	27	24—27 1942/43	28	29	30	31	32	33	28—33 1943/44	34	35	36	37	34—37 1944/45	13—37 All samples
..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	1
..	..	..	..	..	..	..	..	1	..	..	1	..	18	..	..	18	25
..	..	7	3	10	..	..	..	..	..	..	..	3	71	1	32	107	290
4	1	23	18	46	..	5	1	..	28	1	35	11	134	29	112	286	834
26	9	98	76	209	..	52	7	1	140	20	220	25	58	67	67	217	1 004
3	6	39	29	77	..	13	..	..	90	22	125	11	6	6	15	38	541
8	14	23	36	81	..	5	3	..	4	5	17	12	4	1	24	41	729
2	9	1	13	25	3	6	3	..	28	3	43	22	4	2	10	38	436
..	1	..	..	1	3	5	..	..	29	1	38	10	2	1	..	13	121
..	..	..	..	..	1	..	..	..	3	1	5	..	..	..	..	..	10
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
43	40	191	175	449	7	86	14	2	322	53	484	94	298	107	260	759	3 992
8.5	9.6	8.3	8.7	8.6	11.7	8.7	9.0	6.5	8.9	8.9	9.1	9.3	7.0	7.9	7.7	7.6	8.6
230	330	1 000	1 000	2 560	70	510	85	10	1 950	200	2 825	735	860	420	890	2 905	23 570
5.3	8.3	5.2	5.7	5.7	10.0	5.9	6.1	5.0	6.1	3.8	5.8	7.8	2.7	3.9	3.4	3.8	5.9

mingled together in the catches; sometimes one of them is in the majority, sometimes the other.

In the sorting of the Limfjord sprat 8 cm—as mentioned—is considered the lower size limit of sprat to be sold as human food (for smoking or canning). Sprat below this size—at the Limfjord termed "Hjarg"—are sorted off together with the small herring and other waste fishes to be sold to fish meal factories and pond farms.

Normally the small herring and the rest of the waste fish bring only low prices; in the years 1932—39 the average price of small herring was only 2 Øre per kg while the sprat in the same years brought in 12 Øre per kg or 6 times as much. In view of this great difference of price it must be considered very unprofitable that large quantities of small sprat are caught and sold together with the waste fish. The analyses of the Biological Station of catches from the seine fishery show that the amounts of small sprat that are caught and therefore form part of the waste fish are very considerable. It appears from Tables 7 and 8 that 1372 of the 7195 sprat measured, or about 19 %, are less than 8 cm long and accordingly included under the waste fish. If we look at the samples from the sprat trawl alone—the most important gear of the fishery of to-day—the amount of small sprat is even larger, 29 % or between $^1/_4$ and $^1/_3$ of all the sprat landed. It would therefore be very profitable for the sprat fishery if it could be pursued in such a way that these 29 % were spared in the first instance to be fished at a later point of time when their value per kg has increased to the six-fold.

Small herring. The annual quantities of small herring taken by the seiners of the Limfjord are very large. In Table 2 the catch yields are quoted from "Fiskeri-Beretningen", but it should be noted that under "Small herring" down to and including 1942 are counted small sprat and other waste fishes. Accordingly, the figures representing the catches of small herring are a little too high: for 1943 the pure catch of small herring is stated to be 818 tons while small herring + waste fish are reported to amount to about 900 tons; according to these figures the catch amounts for small herring may be considered to be about 10 % too high.

There is a very great variation of the catches from year to year; the lowest yield of these 20 years occurred in 1940 when, according to "Fiskeri-Beretningen", only 20 tons were taken. The highest yields were landed in 1930 with 1050 tons and in 1923 with 1600 tons. During the last 10 years (1934—43) the catch of small herring averaged 364 tons or, taking about 10 % of other waste fish into account, about 330 tons a year. The amount of grown-up herring taken during the same period was 689 tons a year. In weight the catch of small herring is thus half as large as that of adult herring. In number, however, things are quite different. The mean weight of an adult Limfjord herring is about 100 g, that of a small herring about 9 g; a calculation from these figures gives 7 mill. herring and 37 mill. small herring, which means that the number of young herring taken in the Fjord is more than 5 times the number of adult herring.

In other words the quantity of youngs removed by the seine fishery is very large. That this removal has not yet led to a devastation of the herring population of the Fjord is due to the fact that the majority of small herring caught in the Fjord do not belong to the proper stock of the Fjord but have immigrated from the North Sea and will return to this water before they grow adult. A. C. Johansen[1]) says about this fact that "according to various analyses I have made, it must be assumed that the bulk of these "silding" (= small herring) belong to the race of North Sea bank herring.", and further that "although an intensive fishery for "silding" in the Belt Sea and the western Baltic would threaten to diminish the yield of the fishery for adult herring, an intensive fishery for "silding" off the west coast of Jutland and in the western part of the Limfjord would not endanger any of the Danish herring fisheries." Further investigations on the catching of young herring in the waste fish fishery were made by Aage J. C. Jensen[2]), who says, "Normally many youngs of the autumn herring of the North Sea are found in the Limfjord, but youngs of herring spawning in the Fjord and immediately outside Thyborøn also play a considerable part in the fishery for waste fish. An intensification of this fishery in the Limfjord will therefore tend to damage the local fishings for adult herring considerably." The possibility can hardly be totally overlooked that an intense fishing for waste fish in the Limfjord may deteriorate the

[1]) A. C. Johansen: The Aalborg Herring and its Importance to the Danish Herring Fishery from the XVIth Century until the Present Day. Rep. Dan. Biol. St., XXXV, 1929.

[2]) Vestjysk Fiskeritidende, 24.I.1945.

fishing for grown-up herring in the same water. Whether or not this is the case cannot, however, be decided until detailed racial examinations of the herring and small herring of the Limfjord have been carried out by the Biological Station.

The mean lengths of small herring in the samples from the seine fishery were as follows:

Sprat seine	1935—36	10.0 cm	(374 ind.s)
—	1938—39	9.2 -	(323 -)
—	1939—40	11.9 -	(17 -)
Sprat trawl	1940—41	10.9 -	(749 -)
—	1941—42	10.2 -	(483 -)
—	1942—43	9.6 -	(692 -)
—	1943—44	10.5 -	(1366 -)
—	1944—45	10.8 -	(474 -)

The mean lengths of the different years thus range between 9.2 and 11.9 cm. The length of the small herring from the seine is 9.7 cm, from the trawl 10.4 cm, a rather small difference. In the case of the sprat there is also—as mentioned—a small difference, but the other way, the sprat from the seine being a little longer than those from the trawl. The fact that the bag of the latter has a somewhat greater mesh-width (13 mm from knot to knot) than the former (10 mm from knot to knot) in other words has not caused the trawl to take fewer of the small sprat and herring than the seine. Apparently the mesh-width must be much greater than both 10 and 13 mm if we want to avoid that the gear takes small individuals of herring and sprat.

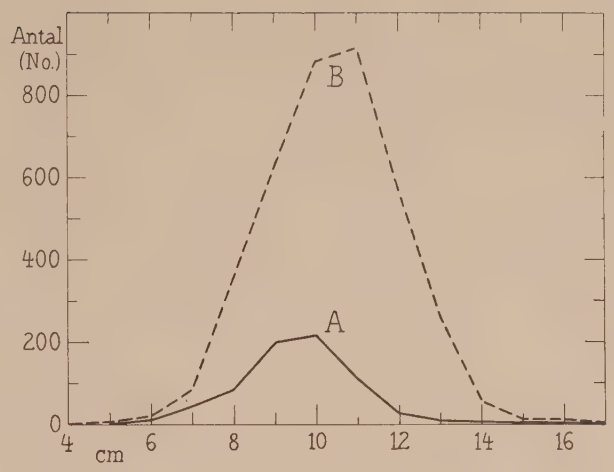


Fig. 5. Lengths of small herring from sprat seines (A) and sprat trawls (B).

Unlike the sprat the small herring (see Tables 9 and 10) cannot be divided into two length or age groups. Fig. 5 gives the length graphs for small herring from all samples caught in sprat seine and sprat trawl. The mean length is about 10—11 cm, the shortest individuals being 5 cm, the longest 17 cm (8 individuals of 18—22 cm were not included in the graphs). On both sides of the top of the graph there is a smooth decline, which seems to indicate that the

Table 9. Lengths in cm of herring caught with the sprat seine in the Limfjord.

Sample No.	1	4	1—4 1935/36	5	6	7	8	5—8 1938/39	9	10	9—10 1939/40	1—10 All samples
6 cm	1	..	1	7	..	1	2	10	..	..	..	11
7 -	1	..	1	20	4	7	12	43	..	..	..	44
8 -	16	3	19	20	7	15	22	64	..	..	..	83
9 -	80	24	104	25	17	19	34	95	..	..	..	199
10 -	92	52	144	17	19	13	19	68	..	1	1	213
11 -	46	31	77	8	8	5	5	26	7	..	7	110
12 -	9	6	15	1	2	1	3	7	3	1	4	26
13 -	2	3	5	..	1	..	1	2	2	..	2	9
14 -	1	1	2	..	..	..	1	1	..	3	3	6
15 -	3	1	4	..	..	..	..	..	..	..	..	4
16 -	..	2	2	..	..	..	..	..	..	..	..	2
17 -	..	..	..	..	..	..	..	..	..	..	..	..
18 -	..	..	..	..	..	..	3	3	..	..	..	3
19 -	..	..	..	..	..	1	1	2	..	..	..	2
20 -	..	..	..	..	..	..	..	..	..	..	..	..
21 -	..	..	..	..	..	..	..	..	..	..	..	..
22 -	..	..	..	..	..	1	1	2	..	..	..	2
Total	251	123	374	98	58	63	104	323	12	5	17	714
Mean length in cm	9.9	10.3	10.0	8.5	9.5	9.3	9.4	9.2	11.6	12.8	11.9	9.7
Grammes	..	900	..	430	300	430	760	1 920	150	80	230	
Grammes /1 ind.	..	7.3	..	4.4	5.2	6.8	7.3	6.0	12.5	16.	13.5	

Table 10. Lengths in cm of herring caug

Sample No.	13	14	15	16	17	18	13—18 1940/41	19	20	21	22	23	19—2 1941
5 cm	..	..	..	..	1	..	1	..	..	..	..	..	..
6 -	..	2	3	..	1	1	7	..	..	..	..	..	..
7 -	..	9	6	..	4	1	20	..	..	..	3	4	7
8 -	16	25	10	..	27	8	86	1	1	1	1	22	26
9 -	7	7	6	1	46	9	76	14	3	..	13	33	63
10 -	17	8	6	..	48	22	101	81	..	1	55	22	159
11 -	9	20	3	2	28	32	94	127	1	..	72	6	206
12 -	39	44	14	5	48	71	221	15	..	..	6	..	21
13 -	15	19	21	5	19	35	114	1	..	..	..	..	1
14 -	4	2	9	..	..	5	20	..	..	..	..	..	..
15 -	..	1	..	1	1	1	4	..	..	..	..	..	..
16 -	..	1	2	..	..	1	4	..	..	..	..	..	..
17 -	..	..	1	..	..	..	1	..	..	..	..	..	..
18 -	..	..	..	..	..	..	..	..	..	..	..	..	..
19 -	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	107	138	81	14	223	186	749	239	5	2	150	87	483
Mean length in cm	11.0	10.7	11.1	12.2	10.3	11.5	10.9	10.6	9.2	9.0	10.4	9.0	10
Grammes	1 150	1 380	880	190	1 900	2 100	7 600	2 300	15	10	1 350	480	4 165
Grammes /1 ind.	10.7	10.0	10.9	13.6	8.5	11.3	10.1	9.6	..	..	9.0	5.5	8

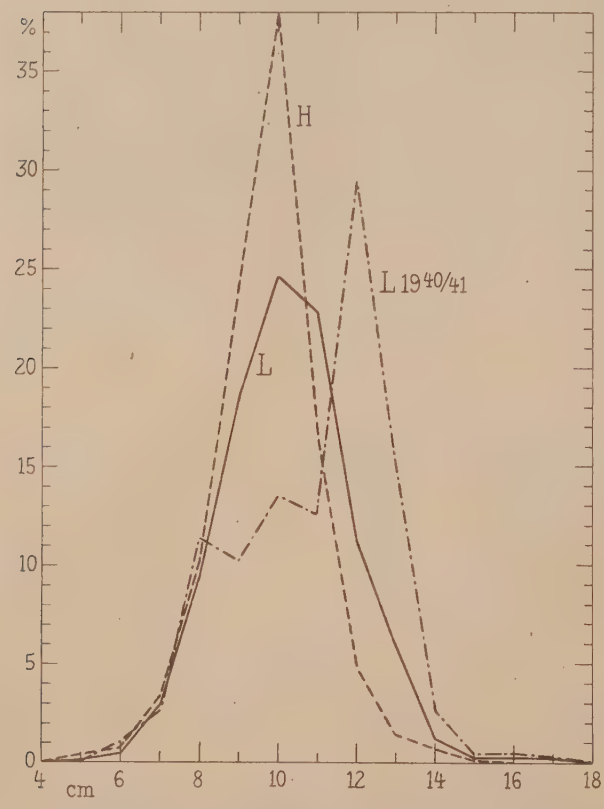


Fig. 6. The percentile distribution of lengths of small herring caught during the winter half-year in the Horns Reef Area (H) and the Limfjord (L) together with the same distribution in the Limfjord for the year 1940/41 alone.

stock which was the object of the fishery is uniform, consisting of only one age group or, since all races do not spawn at the same time, originating from one race. A look at the table, however, which gives the measurements of the individual samples, clearly shows that things are not so simple. If we look for instance at analyses No.s 13—18, it is seen that here the length distribution is very wide, with 2 or 3 tops; obviously these herring cannot originate from one spawning. On the other hand the distances between the tops are not so great that we may class them as different age-groups of the same race. Two samples like No.s 30 and 32, with mean lengths of 9.7 and 12.1 cm cannot either be composed of herring from the same spawning, nor can there be a difference of one year in their age (young herring will grow much more than by 2.5 cm a year). Consequently, the measurements of the samples clearly show that the small herring of the catches originate from different spawning periods and, accordingly, from different races.

The measurings thus corroborate A. C. Johansen's and Aage J. C. Jensen's observations to the effect that the stock of small herring in the Limfjord does not belong to one race but is composed of small herring from different races. It was already mentioned that the youngs of the autumn spawning bank herring of the North Sea make up an essential part of the stock of young herring in the Limfjord, but

h the sprat trawl in the Limfjord.

24	25	26	27	24—27 1942/43	28	29	30	31	32	33	28—33 1943/44	34	35	36	37	34—37 1944/45	13—37 All samples
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
..	..	3	1	4	..	1	1	..	..	..	2	1	..	..	..	1	14
5	1	37	12	55	..	1	3	..	..	..	4	1	2	..	..	3	89
42	12	68	37	159	5	4	32	2	..	9	52	5	6	..	1	12	355
35	24	32	32	123	22	23	114	49	..	37	245	73	40	..	5	118	625
24	46	18	38	126	98	70	93	67	5	60	393	81	19	2	9	111	890
22	42	19	73	156	174	74	32	44	24	50	398	43	5	6	7	61	915
4	6	19	24	53	25	20	23	24	92	27	211	19	2	40	3	64	570
..	1	14	..	15	3	2	4	1	40	7	57	16	..	53	3	72	259
..	..	1	..	1	..	..	..	..	2	2	4	14	..	12	1	27	52
..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	2	6
..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	2	6
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	1
132	132	211	217	692	327	195	302	187	163	192	1 366	257	75	113	29	474	3 764
9.2	10.0	9.1	9.9	9.6	10.6	10.4	9.7	10.2	12.1	10.4	10.5	10.5	9.4	12.6	10.7	10.8	10.4
300	1 040	1 550	1 550	4 940	3 000	1 650	1 900	1 500	2 050	1 500	11 600	2 250	450	1 580	240	4 520	32 825
6.1	8.0	7.0	7.1	7.1	9.2	8.5	6.3	8.0	12.5	7.8	8.5	8.8	6.0	14.0	8.3	9.5	8.7

the incongruous measurements show that the latter also include considerable amounts of young herring of other races, among them also of the races that are indigenous to the Limfjord.

The miscellaneous origin of the Limfjord stock of young herring further appears from a comparison between the measurements of young herring from the Horns Reef Area and from the Limfjord. From the Horns Reef Area we have measurements of youngs of the autumn spawning herring of the North Sea, i.e. of the herring the youngs of which constitute part of the stock of small herring in the Limfjord. Fig. 6 gives the distribution of lengths of 2 409 small herring from the Horns Reef Area and 4 473 small herring from the Limfjord. The small herring of the Limfjord are a little longer than those of the Horns Reef Area, 10.3 against 9.8 cm. Further the graph representing the distribution of the small herring of the Limfjord is somewhat lower and broader than that of the small herring of the Horns Reef Area, which means that the lengths of the individual specimens deviate more from the mean; this is also expressed by the fact that the standard deviation[1]) (a figure illustrating the degree to which the individuals are dispersed on both sides of the mean length) is higher for the small Limfjord herring, 1.58, than for the small herring of the Horns Reef, 1.25. The following standard deviations were found for the measurements of the individual years:

The Limfjord		The Horns Reef Area	
1935—36	1.256 (374 ind.s)	1922—23	1.116 (668 ind.s)
1938—39	1.053 (316 -)	1923—24	1.291 (1128 -)
1940—41	1.919 (749 -)	1924—25	1.118 (211 -)
1941—42	1.018 (483 -)	1930—31	0.866 (402 -)
1942—43	1.562 (692 -)		
1943—44	1.222 (1344 -)		
1944—45	1.734 (474 -)		

In the Horns Reef Area the standard deviation is comparatively low and comparatively uniform from year to year, ranging only between 0.866 and 1.291; in the Limfjord, however, it is comparatively high and more variable, ranging between 1.018 and 1.919. For one year, 1940—41, the deviation is so wide, that the distribution graph alone (Fig. 6) very distinctly shows us that we are dealing with a mingled stock. It is therefore ovbious that the stock of small herring in the Limfjord is composed of 2 or more races.

In other words the high standard deviation as well as the heterogeneous character of the individual samples show that the Limfjord stock of small herring is highly intermingled, so that one race is not always predominant. It is therefore very probable that a considerable part of the small herring caught belong to local races of the Limfjord and that a too

[1]) $\sigma = \sqrt{\frac{\Sigma pa^2}{n} \div b^2}$

intense fishing for small herring (waste fish) may prove to be damaging to the herring fishery of the Limfjord.

Throughout the last 25 years (Table 2) there has been a rapid decrease in the yield of the herring fishery in the Limfjord, from 2—3 000 tons at the beginning of the twenties to barely 1000 tons at the beginning of the forties; in the years 1941—44, however, the fall of the yield was not so rapid in the Limfjord as in the other Danish waters (H. Blegvad[1])). But it is characteristic of the herring fisheries as a whole that their yields from one series of years to the next is highly variable. Accordingly, the decrease in the yield of the herring fishery of the Limfjord during these 25 years is not necessarily a consequence of a too intense fishing for waste fish though it calls attention to this problem.

Conclusion.

For several centuries a herring fishery with seine has been going on in the Limfjord, and we know that heavy catches of waste fish, especially small herring, were the result of this fishery, not only in recent but also in older times.

Until about 30 years ago the gear used for this fishery was the shore seine, but during the following years this old gear was completely replaced by two more intensely fishing gears: the sprat seine and the sprat trawl. Already before the introduction of these two gears the value of the small fish (small herring and sprat) had become apparent, and gradually the old herring seine, which used to be one of the principal gears for fishing adult herring, got a smaller mesh-width and thus became better suited for the catching of small herring and sprat. Gradually a good market for these two fishes was worked up: the small herring were used partly as bait, partly as fish fodder or for fish meal and (for certain periods) also for canning, and the sprat were sold to smokehouses or canning factories. The remaining catches of small fish—mostly small sprat—were sold together with the small herring.

With the increasing market for waste fish and sprat the desire arose of getting a more efficient gear than the old shore seine. During the twenties it became usual to diminish the mesh-width of the bag of the Danish cod seine and use it for the waste fish fishery. During the same years the cod population decreased very much; the Danish seines came to be used nearly exclusively for the catching of small herring and sprat, and so the term "sprat seine" became a common name of this gear, for the use of which special regulations were established by the authorities. But the fishermen soon found that this gear did not either give satisfaction, and in 1939 it was therefore permitted to use a dragging gear, the so-called sprat trawl, with a minimum mesh-width of 13 mm (see p. 7) for the catching of sprat, small herring and waste fish in the Limfjord. The use of sprat seines and shore seines is now quite exceptional.

As there seemed to be some reason for the belief that the use of so fine-meshed gears as the sprat seine and the sprat trawl would mean the destruction of considerable quantities of the youngs of valuable commercial fishes like flat-fish and cod, the Biological Station for a long series of years has been making analyses of catches from the two gears.

The principal result of these investigations appears from Fig. 2. The bulk of the catches, about 85—90 %, consisted of small herring and sprat. Quite exceptionally small quantities of young cod and whiting would occur in the seines. The catches of other fishes, for instance youngs of flat-fish, were always insignificant. In certain cases, therefore, the fishery with these gears may damage the cod population while all other fishes—naturally apart from herring and sprat—are not affected by this fishery.

Large quantities of young herring are removed by the seine fishery; calculations based on analyses tell us that an average of about 37 mill. small herring are caught per year. The catches of grown-up herring in the Fjord amount to nearly 7 mill. specimens a year. Only the fact that an essential part of the small herring caught in the Limfjord have immigrated from the North Sea, to which the rest of them will return before reaching the adult stage, has prevented the herring fishery of the Limfjord from being spoiled a long time ago.

It cannot be decided at present how large a portion of the small herring caught in the Fjord belong to the herring population of the North Sea. Quite apart from this the ratio between the quantities of young North Sea herring and young Limfjord herring in the catches is of less importance if we want to estimate the degree to which the herring population

[1]) H. Blegvad: On the Waste Fish Fishery. Rep. Dan. Biol. St., XLVIII, 1945.

of the Limfjord is damaged by this fishery since it takes its share of the young Limfjord herring, no matter how many young North Sea herring are present. But an examination of the races of the young herring of the Fjord is desirable because there is a possibility that the North Sea herring principally occur within certain areas—probably those near Thyborøn—and that the indigenous youngs of the Limfjord are mainly found in the inner parts of the Fjord. If this be the case, a limitation of the extensive young herring fishery to the western areas will be expedient.

Whether or not the herring population of the Limfjord in the long run can endure the draining to which it is exposed by the fishing for young herring cannot be answered at present. Only the experiences gained by continuously following the development of both the small herring and the waste fish fisheries can possibly contribute to the solution of this problem. Though, in other words, there is not yet any final answer to this question, there is every reason to be on the alert against an extensive fishing for small herring in the Limfjord. An increase of the minimum mesh-width of the trawls is no doubt desirable because it will mean a protection of the smallest and least valuable of the young herring.

The dates of the sprat differ from those of the small herring. According to our present knowledge the migrations of the young sprat are not so long as those of the young herring, which justifies the supposition that the sprat found in the Limfjord—both large and small—belong to the proper stock of the Fjord. This again means that there is sufficient reason to protect the young sprat as much as possible, so that it is allowed to reach a size at which it can some time be sold as human food and fetch a price higher than that of the waste fish. In 1939 the waste fish yielded only $2^1/_2$ Øre per kg, while the large sprat brought in 11 Øre per kg. In 1938 the difference of price was still greater: $2^1/_3$ Øre per kg of waste fish against 21 Øre per kg of sprat.

As mentioned on p. 20 the lower size limit of sprat used for human food is 8 cm; the fish below this size are sold as waste fish. According to the analyses 30 % of the sprat of the catches are less than 8 cm long, which means that they are sold at prices amounting to only $^1/_5$—$^1/_9$ of the price of larger sprat. This is obviously an objectionable state of things: the sprat population is reduced because so many sprat are removed before they have spawned (sprat caught during the winter half-year at sizes of less than 8 cm have not yet spawned), and the yield of the sprat fishery is depreciated.

These considerations make it likely that the sprat fishery and, to a less degree, the herring fishery will benefit from an increase of the present mesh-width of the sprat trawl. In this connexion it should be mentioned that in the sprat trawls used along the German coast of the Baltic[1]) the mesh-width of the bag varies between 10 and 18 mm, according to local conditions. The German investigations show that even with a mesh-width of 18 mm large quantities of sprat and small herring are taken down to a size of 8 cm, but only few below this size. If we want to secure some degree of protection of small sprat and small herring, it will probably be necessary to increase the mesh width of the bags to about 18 mm. But it will of course be necessary first to experiment in Danish waters on the suitable mesh-width, and for these experiments it will be reasonable to use mesh-widths of 13—18 mm in the bags.

[1]) P. F. Meyer: Die Zeesenfischerei auf Hering und Spratt, ihre Entwicklung und Bedeutung für die Ostseefischerei und ihre Auswirkungen auf den Blankfischbestand der Ostsee. Zeitschrift für Fischerei, Band XL, H. 4—5, 1943.

First Report

on

The Effect of the Liberation of Salmon Fry in the Gudenaa 1946–47.

By

KNUD LARSEN

As mentioned in a previous paper (Knud Larsen, 1942) liberations of sea trout (and to a smaller extent salmon) fry in Danish water-courses have been carried out for a series of years on the principles planned by C. V. Otterstrøm (1933 and 1937). Apart from some years of the last war when the difficulties in distributing the fry grew too great on account of the restrictions of transport the liberations have been carried out according to schedule year by year in most of the water-courses for which plans of liberation exist. Up to now, however, it has not been possible —in spite of a great need for it— to form an absolutely reliable image of the effect of the liberations (particularly of sea trout because the extent of the liberations of salmon has hitherto been too small to justify the expectation of an essential effect on the catches). In some localities the opinion prevails that the stock has not increased though on the other hand it has not decreased either, a fact which may perhaps be considered a positive effect in view of the interfering with the water-courses in the form of regulations, lowerings of water levels and pollutions. Elsewhere there is an impression that the stock of sea trout has increased though the increase cannot be expressed in figures. As far as the author knows the only place where this has been done in this country is Grenaa (Oscar Larsen in "Sportsfiskeren", 1947, p. 79) where we find a steady rise of the quantity of sea trout landed at the harbour of Grenaa from 1929 to 1944. However, in view of the fact that liberations after the principles of Otterstrøm were carried out for the first time in the river Grenaaen in 1943 while the local association of fishermen had performed liberations since 1928, the rise of the catches of sea trout so far observed cannot naturally be due to the modern method of liberation. On the other hand it is of course impossible to decide whether it is caused by methodical liberations of fry in other water-courses of the east coast of Jutland than in the river Grenaaen or it is the effect of liberations in this stream before 1943[1]).

It soon became clear to the author that if the effect of the liberation of fry with any degree of accuracy were to be measured through increased catches, experimental liberations could not at any rate be made with the fry of sea trout because the natural trout population by its undoubtedly varying production of young fish for the stock of sea trout will easily tend to veil the effect of the liberation on the yield of the fishery in the lower stream and the sea without. Nothing, however, spoke against carrying out the experiments with young salmon if a water area could be found in which no population of salmon existed already, but where on the other hand the fishermen at the lower stream and the sea without were able to distinguish between salmon and sea trout. It must finally be a condition of the favourable progress of the liberation experiments that accurate statistics of catches are kept for the water area in its widest sense, i. e. both the stream and the adjacent areas of the sea.

With these conditions in mind the Gudenaa must be chosen as an experimental water. In former times this river was the only stream of the east coast of Jutland that contained a rich salmon population (A. C. Johansen and J. Chr. Løfting, 1919), but the building of the generating station at Tange in 1920 barred the way to the spawning places of the salmon, all of which localities were situated above the dam of the station; the salmon population was rooted out, and after 1929 no salmon or only one or two of them were caught annually in the Gudenaa and Randers Fjord (E. M. Poulsen, 1935). It must be supposed, however, not only that the fishermen of the area are still able to distinguish between salmon and sea trout, but that, in view of the present

[1]) An earlier Danish attempt to state the effect of the liberation of trout fry and halfyearlings (mentioned in the Fisheries Reports 1920—25) has obviously been without result.

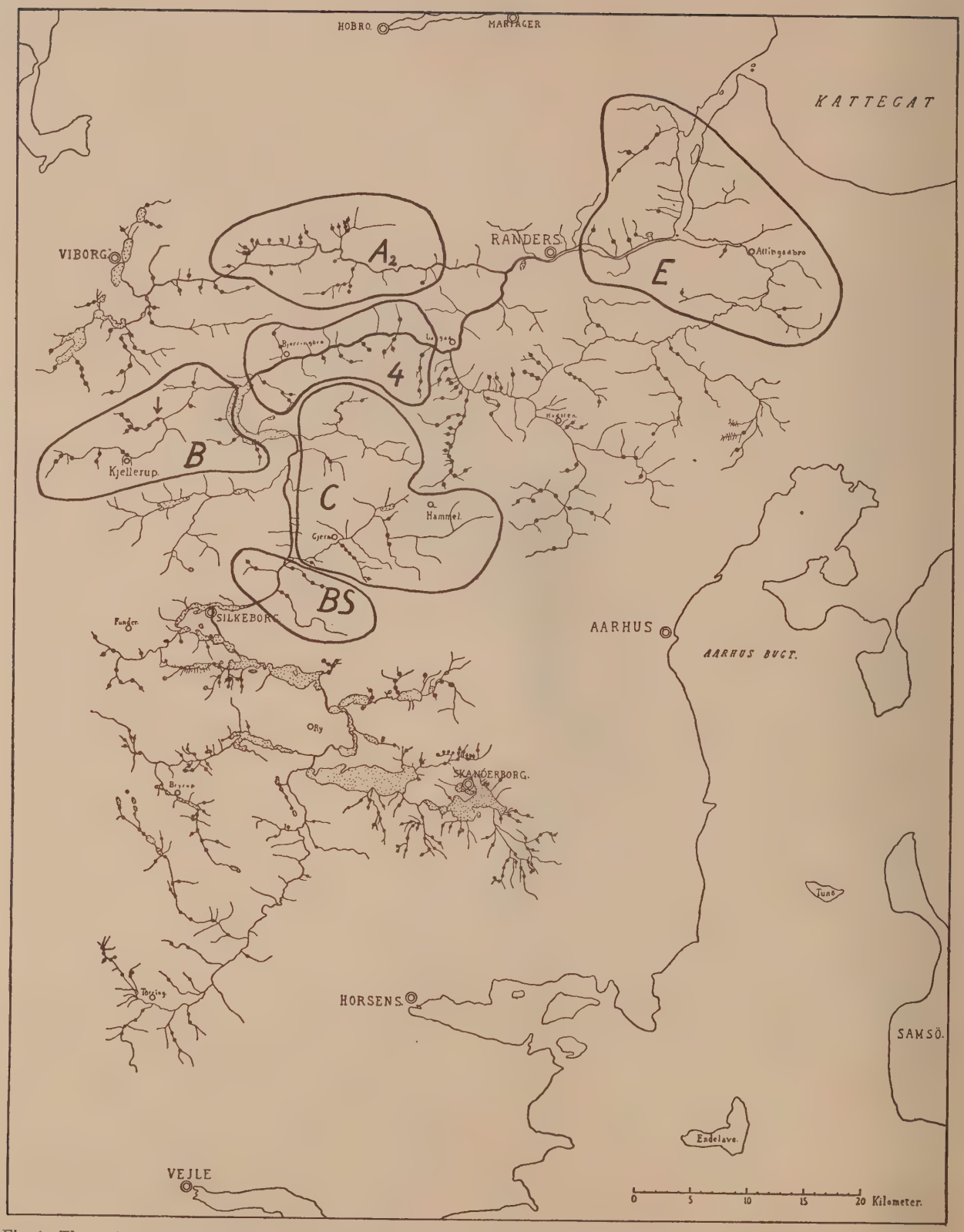


Fig. 1. The water area of the Gudenaa with indication of the liberation areas mentioned in the text. The black points denote the 386 liberation localities proposed in the plan of liberation for the Gudenaa.

infrequency of salmon in the river, they will notice practically every capture of salmon and report it to the Inspection of Fisheries, which keeps the fishery statistics for the fjord and the lower part of the river.

It now remained to provide a suitable number of salmon fry to be liberated according to the plan worked up for the Gudenaa Area. It was impossible to find them in this country where the gaining of salmon roe is inconsiderable and does not take place at all in some years; and after the war monetary conditions *a priori* made it impossible to buy salmon roe abroad.

During a study tour to Sweden in the summer of 1945 the author discussed the matter with fil. dr. Gunnar Alm, the Swedish fishery biologist, who obtained from Kungl. Lantbruksstyrelsen that 100 000 pieces of salmon roe were placed at our disposal gratuitously for experimental liberations in 1946. In the following year Kungl. Lantbruksstyrelsen presented us with further 100 000 pieces of salmon roe for the continuation of the experiments in 1947, and a short time ago we received an offer of a similar number in 1948 also. I wish to render our best thanks for this highly appreciated Swedish understanding and help to the Danish fishery investigations.

The salmon roe in 1946 and 1947 originated from fish caught in Mörrumsån in Blekinge. It was hatched to the eyed ova-stage in the hatchery of Mörrum and then sent to Denmark where the hatching was continued in the hatchery of the Tange Generating Station.

After the hatching the salmon fry were liberated according to Otterstrøm's principles in tributaries of the Gudenaa conformably to the subjoined plan (cp. Fig. 1). The fry liberated in 1946 still had a good deal of the yolk-sac left while the liberation in 1947 was postponed until the greater part of the yolk-sac was consumed.

For the valuation of the following it is necessary to state that in the spring of 1947 3 000 pieces of fry were distributed in Area B in the liberation

Liberations of Salmon fry in Tributaries of the Gudenaa.

1946		1947	
Area of liberation	Number	Area of liberation	Number
A_2	24 500	A_2	25 000
B minus the 5 westernmost localities of liberation	15 600	B minus the locality of liberation N. of Kjellerup	20 000
C	17 000	C	18 500
E minus the 4 southeasternmost localities of liberation	10 300	E minus the 4 southeasternmost localities of liberation	10 000
4	19 000	4	20 000
B.S. minus the 2 southernmost localities of liberation	6 500	B.S.	6 500
Total	91 900	Total	100 000

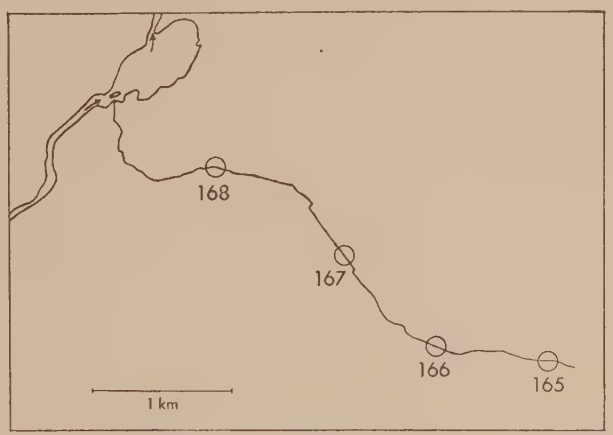


Fig. 2. Detail map of the Voel Bæk with the liberation localities 165—168. At the top left the Gudenaa and the lake Sminge Sø; the arrows indicate the direction of current.

locality of the main stream of Tange Aa N.W. of Kjellerup (below Humlemølle) while, as mentioned, no liberation took place in the liberation locality immediately N. of Kjellerup (at the Kjellerup-Viborg road); in the easternmost liberation locality of the Levring Bæk in Area B (at the Levring-Rødkjærsbro road, indicated by an arrow in Fig. 1) 2 000 pieces of fry were distributed with the majority above the road and the rest below. In the Voel Bæk, finally, in Area B. S. the following numbers were liberated (cp. Fig. 2):

From St. 166 and halfway upwards to St. 165	600	pieces	of fry
From St. 166 and about 200 m downwards	2 000	—	—
At St. 167, distributed up- and downwards	1 000	—	—

After the termination of the liberations it was intended to await the time at which the salmon would come to be caught during their ascent through the Randers Fjord and the lower Gudenaa, thus appearing in the fishery statistics. As regards the summer salmon, the A-group (Johansen and Løfting, l. c.), the capture broadly speaking would begin in 1949; in 1950 salmon of the A- and B-groups would come to be captured, in 1951 salmon of the

B- and C-groups and in 1952 presumably salmon of the C-group only, the D-group at any rate formerly being extremely rare within this area. It is true that deviations in the length of the stay in fresh water may alter both the years of capture and the distribution of the age groups in the years in question, but the effects of this will be inconsiderable; an ascent of fish originating from the two liberations cannot be expected to take place before the summer of 1948, neither will any considerable ascent take place after 1953.

It must be emphasized at once that in the catches of salmon in the Gudenaa and Randers Fjord in the years 1948—53 only a rise to yields considerably above the upper limits of the fluctuations from 1929 to 1948 will give a reliable picture of the importance of the liberations of fry. However, the lack of a rise in the catches or a total absence of salmon in the fjord and the lower river cannot alone be considered expressive of the ineffectuality of the liberations. For though there is a moral certainty that practically all captures of salmon in the river and the fjord during these years will be registered, there is a theoretical possibility that this will not take place. And finally it is possible—perhaps even probable—that the majority of the salmon originating from the liberations will be caught elsewhere, for instance during migrations along the east coast of Jutland, in which case they will of course not appear in the statistics for the Randers Fjord and Gudenaa. And it will be too optimistic to expect that liberations of fry on so small a scale as the present one will be perceptible in the total catches of salmon in the Kattegat to such an extent that it is legitimate to draw any conclusions on their size order. When carried out in the way planned the experiment can only tend to show what a liberation of salmon fry in the Gudenaa means in the catches from the lower part of the river and the Randers Fjord.

Fortunately it was not necessary to wait until 1948—49 for the first results of the liberation. In 1944 "Svenska lax- och laxöringföreningen" started some large-scale investigations on the effects of liberations of salmon and trout fry in the river Kävlingeå in Schonen (Ph. Wolf, 1944 and 1946), and for this purpose the association during recent years has been using an electric fishing apparatus, which in small streams is able to catch the whole stock of fish without hurting it (Ph. Wolf, 1947). With this electric fishing apparatus it is not only possible before the liberation of fry to remove all enemies of the fry from the stream, but the effect of the liberation can be controlled at will in the very streams of liberation, and after registration the fish can be re-liberated intact. In the spring of 1947 Svenska lax- och laxöringföreningen offered to lend out the apparatus with the necessary personnel for a preliminary examination of the effect of the Danish liberations of salmon fry in the Gudenaa Area. The offer was accepted with thanks, and on October 4th—5th, 1947, experimental fishings were carried out in 4 sections of the Voel Bæk in Area B. S., 2 sections of the Levring Bæk and 2 sections of the Tange Aa at Kjellerup, both in Area B. Each section covered 75 m of the brook or river. The situation of the sections, the nature of the streams and the amounts of capture were as follows:

1. The Voel Bæk.

Section 1. From the Voel—Skannerup road (St. 166) and 75 m down the stream (Fig. 3). The brook about $^1/_2$ m broad and up to 20 cm deep with ample vegetation and small pools. Current: rapid. Bottom: sand and gravel.

Section 2. From the Voel—Skannerup road (St. 166) and 75 m upwards. Dimensions as in Sect. 1, but sparse vegetation and no pools. Bottom: sand and gravel.

Section 3. From the Voel—Tvilum road (St. 167) and 75 m downwards (Fig. 4). The brook of uniform breadth, 1.35 m, about 10 cm deep. Regulated in 1946. Almost no vegetation. Current: rapid. Bottom: gravelly with a few stones.

Section 4. From the Voel—Tvilum road (St. 167) and 75 m upwards (Fig. 5). The brook about 0.9 m broad, about 20 cm deep. Not regulated, natural run. Rich vegetation and deep pools. Rapid current. Bottom: mostly sand, but with a few big stones.

Catches in the Voel Bæk.

Section No.	Salmon 0-Gr. Number	Salmon 0-Gr. Length in mm	Salmon I-Gr. Number	Trout Number	Trout Length in mm	Eel Number	Burbot Number	Burbot Length in mm	Salmon or trout Number
1	4	86–104	..	..	..	..	..	..	..
2	1	110	..	3	81–164	..	..	..	..
3	55	57–115	..	5	80–178	..	2	280–290	4[1])
4	11	76–116	..	34	113–285	6	..	..	1[1])

[1]) Observed but not captured.

2. The Levring Bæk.

Section 1. From the Levring—Rødkjærsbro road and 75 m downwards (Fig. 6). The brook about 1 m broad, about 12 cm deep. Not regulated, natural run.

Good vegetation of Sium, a few alders. Current: good—rapid. Bottom: alternately stony, gravelly, sandy and soft. Slight indications of pollution.

Section 2. From the Levring—Rødkjærsbro road and 75 m upwards. The brook about 1 m broad, about 20 cm deep. Not regulated, natural run. Good vegetation. Current: good. Bottom: gravelly-sandy-soft. Slight indications of pollution.

Catches in the Levring Bæk.

Section No.	Salmon 0-Gr. Number	Salmon 0-Gr. Length in mm	Salmon I-Gr. Number	Trout Number	Trout Length in mm	Eel Number	3-spined stickleback Number	Crucian carp Number
1	29	67–112	..	20	118–209	3	3	20
2	54	68–125	..	15	126–206	6	7	3

3. The Tange Aa.

Section 1. From the lower border of the backwater pool at Humlemølle and 75 m downwards (Fig. 7). The river about $3^1/_2$ m broad, 10—15 cm deep. Not regulated, natural run. Vegetation in cushions, consisting of Myriophyllum and Callitriche. Current varying from smooth to rapid according to the use of the mill. Bottom: mostly gravelly. Water: somewhat cloudy, presumably from contents of iron or manganese salts.

Section 2. From the Kjellerup—Viborg road and 75 m upwards (Fig. 8). The river $3^1/_2$—4 m broad, 25—40 cm deep. Vegetation sparse; scattered cushions of Myriophyllum and Callitriche. Current as in Sect. 1. Some few metres near the road with gravelly bottom, otherwise soft bottom with precipitated iron or manganese compounds (ochre). Water: as in Sect. 1.

Catches in the Tange Aa.

Section No.	Salmon 0-Gr. Number	Salmon 0-Gr. Length in mm	Salmon I-Gr. Number	Trout Number	Trout Length in mm	Eel Number	3-spined stickleback Number	Minnow Number	Salmon or trout Number
1[1]	9	80–109	..	2	178–202	4	..	4	..
2	..	..	..	..	..	2	12	13	1[2]

[1]) In the backwater pool at the mill (above the section) some large trout were standing; 2 of them measured $24^1/_2$ and 33 cm.
[2]) Observed but not captured.

A valuation of the catches at once makes it clear that the liberation of salmon fry in 1947 is far from being ineffective in the streams of liberation. In some localities (the Voel Bæk, Section 3 and the Levring Bæk) the recapture of 1-summer-salmon even exceeded the most sanguine expectations. In Sections 1 and 2, in part also Section 4 of the Voel Bæk and Section 1 of the Tange Aa, however, the catches were smaller than might be expected from the nature of the streams. The causes of this do not appear directly from the present investigation, but if we compare the result with experiences from the much more detailed investigations in Kävlingeån as published by Wolf (1947) or communicated to me verbally, we begin to understand the facts of the case.

A look at the Voel Bæk as a whole reveals the conspicuous fact that the stock of 1-summer-salmon in autumn is smaller in the upper and larger in the lower course of the brook in spite of the fact that equal amounts of fry per 1 regional unit were liberated throughout the length of the brook. To the uncritical mind this would seem to mean that the upper parts of the streams have been overvalued as places of liberation, that the greater part of the fry is lost here and that, in future liberations, the parts of the brooks should be preferred in which the breadth is 1 m or more. But this is no doubt a wrong interpretation of things. During the liberation of fry and the following fishing by means of electricity in Skogsmöllebäcken, a tributary of Kävlingeån, it has been observed that the salmon (in contrast to the trout, which is decidedly stationary for at least 6 months after the liberation) shows a desire or tendency of descending (Wolf, 1947, Diagram 4), which gradually removes the stock of the stream in a downward direction as the fry grows up. A dry summer like that of 1947 will no doubt stimulate this tendency to descend. Ph. Wolf has told me that the tendency to descend according to experiences from Kävlingeån seems to exist throughout the stay of the salmon as young fish in the streams. In other words the descent of the young salmon into the sea can hardly be regarded in the usual way: that all the young fish at a certain time in spring leave the stream of their youth and begin to emigrate into the main stream and the sea. On the contrary the experiences mentioned above seem to show that the emigration from river to sea, at any rate of a great part of the young fish, only means the termination of a gradual descent, which begins already some time after the hatching or the liberation of the fry.

Wolf is of opinion that the fry are stationary at the place of liberation for the first 4 or 5 weeks, after which time the tendency to descend begins to make itself felt. During these first weeks of life the fry no doubt suffer their heaviest losses if enemies of the fry are found in the locality of liberation.

According to these experiences the liberation of

Fig. 3. The Voel Bæk, Section 1. Viewed in the direction of the current.

Fig. 4. The Voel Bæk, Section 3. Viewed in the direction of the current. The electric fishing is going on.

Fig. 5. The Voel Bæk, Section 4. Viewed against the direction of the current.

Fig. 6. The Levring Bæk, Section 1. Viewed against the direction of the current.

Fig. 7. The Tange Aa, Section 1. Viewed in the direction of the current.

Fig. 8. The Tange Aa, Section 2. Viewed in the direction of the current. On the bridge the jeep with the trailer carrying dynamo and motor. The electric fishing is going on in the river. Person No. 3 from the left (with the wire roll on his back) is carrying the electrode through the water with his left hand.

salmon fry in the upper end of a small stream after some time would result in an increased stock of young fish in the lower part of the stream; this is what seems to have taken place in the Voel Bæk and—presumably—also in the Levring Bæk.

The complete absence of I-group salmon in the streams of liberation accordingly cannot surprise. There is no reason to believe that the liberation of 1946 was less efficient than that of 1947, but presumably the salmon from the 1946 liberation have now migrated from the waters in which they were liberated into the larger rivers.

This rapid descent from the waters of liberation is of very great importance for the restoration of the salmon population through liberations of fry as it must be supposed that the value of the liberations depends on the size of the production of 1-summer-salmon. A "pure" brook where there are no other species of fish than the salmon liberated may thus be used for annual liberations without any risk that salmon remaining from liberations of previous years will compete with the new fry for food or will eat what they can of this fry, which are comparatively defenceless during the first time after their liberation. In this respect the salmon is much better than the sea trout, which, as will also appear from the present fishing experiments, to a great extent remain in the water of liberation for several years, thus contributing to eliminate the effect of new liberations through competition for food and consumption of the fry. Under otherwise equal conditions the liberation of salmon fry in the small water-courses must give a much more profitable utilization of the existing food than the liberation of trout fry.

The absence of young salmon in Section 2 of the Tange Aa must no doubt mean—as might be expected—that this locality is no suitable water for salmon. It was already mentioned that no liberation took place here, but there was a possibility that salmon from the liberation below Humlemølle might have descended to this place. In the same way there can hardly be a difference of opinion on the cause of the scantiness of the stock of Section 4 in the Voel Bæk. Wolf (1947, Diagram 5) has shown that the effect of liberations of salmon and trout fry is perceptibly diminished when comparatively considerable amounts of larger fish, particularly "brook" trout, are present in the waters of liberation. In Section 4 of the Voel Bæk 34 trout were caught, 29 of which measured more than 15 cm; there is no doubt that this large stock of trout have preyed extensively upon the small salmon liberated here or arriving from above. In Section 3, where the production was not limited by this factor because there were no hiding places for the larger trout in the regulated brook the number of 1-summer-salmon captured was 5 times greater in spite of the fact that the stream here is not overshadowed and contains no shelters for the fish; according to Wolf (1947, Diagrams 4 and 5) this fact—all other things being equal—usually induces a smaller production of parr than in overshadowed streams with many hiding places. Similar considerations may be made with regard to Section 1 of the Tange Aa. It is true that the catch of large trout in the section was not remarkably great, but this is explained by the fact that the fishing was carried out while Humlemølle was stopped, so that the flow of the river was slow and the trout had therefore withdrawn to the backwater pool above the section where their presence was observed. On previous occasions the author has seen numerous large trout in the section at times when the mill was running. The catch in the Levring Bæk though less distinctly shows the same state of things: the more large "brook" trout, the poorer the recapture of 1-summer-salmon. If we compare this with corresponding and often less ambiguous experiments from the Kävlingeå, the conclusion to be drawn must be that we cannot expect to get the great results from the liberations of fry until, by a complete exhaustion or by poisoning, the waters of liberation have been emptied of enemies of the fry, especially trout.

A fact which is of no importance in this connexion, but which—if it passed without comment—might give rise to an erroneous valuation of the Levring Bæk, is the occurrence of crucian carp which normally should not be found in a water of this type. The occurrence is no doubt the result of a liberation during the summer. Corresponding findings of crucian carp in the autumn of 1947, even in very considerable quantities, in a rapidly running trout brook is known from another locality, the Klokkedalsbæk on the southern side of the Horsens Fjord. Here the occurrence with certainty could be traced to liberations of crucian carp from a drying-up watering pond at the village of Uth (communicated by mag. scient. E. W. Kaiser, Horsens).

Compared with the results of similar experiments in the Kävlingeå the experiments described above have hitherto shown

i. that the liberation of salmon fry in smaller watercourses ad modo Otterstrøm increases the stock of 1-summer-salmon in the streams,
ii. that we get the greatest increase of the stock of 1-summer-salmon by the smallest population of stationary trout, and
iii. that the parr in the course of about 1 year emigrate from the smaller streams thus leaving favourable conditions for the fry liberated next year.

For further investigations of this kind—also concerning the fry of sea trout—it would be of great help to get one or a few small streams for experimental purposes and to get an apparatus for electric fishing, so that this important part of the work of restoring the stocks of salmon and trout can be continued independently of the possibility of borrowing such apparatuses from abroad and of the time at which they can be had.

Literature.

Johansen, A. C. and J. Chr. Løfting, 1919: Om Fiskebestanden og Fiskeriet i Gudenaaens nedre Løb og Randers Fjord I. (On the Fishes and Fisheries in the Gudenaa and Randers Fjord. Jutland I). (Skrifter udg. af Komm. for Havundersøgelser, No. 9).

Larsen, Knud, 1942: The Liberation of Salmon and Trout Fry in Denmark. (Rep. Dan. Biol. St., XLVII).

Otterstrøm, C. V., 1933: Planmæssig Udsætning af Ørredyngel i Vandløb (Methodical Liberation of Trout Fry in Water-Courses). (Ferskvandsfiskeribladet, 31. Aarg., No.s 2—3).

Otterstrøm, C. V., 1937: On Methodical Liberations of Salmon and Trout Fry in Water-Courses with Special Reference to the Gudenaa Area (Rep. Dan. Biol. St., XLII).

Poulsen, E. M., 1935: Recent Investigations into the Stock of Salmon and Sea Trout in the River Gudenaa. (Rep. Dan. Biol. St., XL).

Wolf, Ph., 1944: Försöksverksamheten i Kävlingeåns vattensystem år 1944. Malmö.

— 1946: Lax och laxöring i Kävlingeån. (Skrifter utgivna av Svenska lax- och laxöringföreningen I.).

— 1947: Lax i Sverige och England. (ibid. III).

found on or in the sea bottom in Danish waters. III. *C. G. Joh. Petersen:* The Work of the Biological Station from 1889—1914. With Illustrations and Tables. 88 pp. IV. *The same:* Appendix to Report XXI. With 2 Charts. 7 pp. On the distribution of the Animal Communities on the Sea Bottom. 1914.

XXIII. *C. G. Joh. Petersen:* On the Animal Communities of the Sea Bottom in the Skagerak, the Christiania Fjord and the Danish waters. With one Chart and four Tables. 29 pp. 1915.

XXIV. I. *C. G. Joh. Petersen:* On the Development of our Common Gobies (*Gobius*) from the Egg to the Adult Stages etc. With 1 Plate and 3 Figures in Text. II. *H. Blegvad:* On the Food of Fish in the Danish Waters within The Skaw. 72 pp. 1916.

XXV. *C. G. Joh. Petersen:* The Sea Bottom and its production of Fish-Food. A survey of the work done in connection with valuation of the Danish waters from 1883—1917. With 12 Plates and 1 Chart. 82 pp. 1918.

XXVI. I. *P. Boysen Jensen:* Valuation of the Limfjord. Studies on the Fish-Food in the Limfjord 1909—1917, its Quantity, Variation and Annual Production. With 7 Plates and 1 Chart. II. *C. G. Joh. Petersen:* Our Gobies *(Gobiidæ).* From the Egg to the Adult Stages. With 3 Plates. 65 pp. 1919.

XXVII. *C. G. Joh. Petersen:* On the stock of Plaice in relation to the intensive fishing of the present times in the Beltsea and other waters. With 2 Plates. 21 pp. 1920.

XXVIII. *H. Blegvad:* On the Biology of some Danish Gammarids and Mysids. *(Gammarus locusta, Mysis flexuosa, Mysis neglecta, Mysis inermis.)* With 5 Tables. 102 pp. 1922.

XXIX. *C. G. Joh. Petersen:* On the Stock of Plaice and the Plaice Fisheries in different Waters. With 2 Charts and 1 Appendix. 42 pp. 1922.

XXX. *R. Spärck:* Studies on the Biology of the Oyster *(Ostrea edulis)* in the Limfjord, with special Reference to the Influence of Temperature on the Sex Change. 80 pp. 1925.

XXXI. I. *C. G. Joh. Petersen:* The Influence of Fishing upon the Stock of Plaice in the Baltic during recent Years. — II. *R. Spärck:* Investigations on the Size of the Stock of Oysters in the Limfjord 1924. — III. *C. G. Joh. Petersen:* Report to the Ministry of Agriculture concerning increased Motor-Fishing in the Limfjord. — IV. *H. Blegvad:* Continued Studies on the Quantity of Fish-Food in the Sea Bottom. — V. *R. Spärck:* A Comparison between the Danish Oyster-Beds and those in Holland and the South-West of France. 63 pp. 1925.

XXXII. *H. Blegvad:* On the Renewal of the Stock of Plaice in the Baltic proper. 37 pp. 1927.

XXXIII. I. *A. C. Johansen:* On the Fluctuations in the Quantity of Young Fry among Plaice and certain other species of fish, and causes of the same. With 7 figures and 1 table. — II. *A. C. Johansen:* On a Spawning Place for winter spawning Herring in the northern part of the Belt Sea. With 2 figures. — III. *H. Blegvad:* On the Annual Fluctuations in the Age-composition of the stock of Plaice. With 2 figures. — IV. *R. Spärck:* Studies on the Biology of the Oyster *(Ostrea edulis)* II—IV. 65 pp. 1927.

XXXIV. I. *R. Spärck:* Studies on the Biology on the Oyster (*Ostrea edulis*) V. — II. *Aage J. C. Jensen:* Remarks on the Hydrography of the Limfjord. With 10 figures and 1 table. — III. *H. Blegvad:* Quantitative Investigations of Bottom Invertebrates in the Limfjord 1910—1927 with Special Reference to the Plaice-Food. With 2 figures and 2 tables. — IV. *A. C. Johansen:* The Extent of the Annual Transplantations of Plaice in the Limfjord and the Yield resulting therefrom. With 11 figures and 12 tables. — V. *Aage J. C. Jensen:* The Relation between the Size of the Plaice Stock and the Quantity of "First Class Plaice-Food" in certain Parts of the Limfjord. With 3 figures and 2 tables. — VI. *Erik M. Poulsen:* The Haddock in the Belt Sea and the Western Baltic during the Years 1926—28. With 4 figures and 8 tables. 125 pp. 1928.

XXXV. I. *A. C. Johansen:* The Aalborg Herring and its Importance to the Danish Herring Fishery from the XVIth Century until the Present Day. With 2 figures and 5 tables. II. *H. Blegvad:* Mortality among Animals of the Littoral Region in Ice Winters. With 3 figures. III. *A. C. Johansen:* Mortality among Porpoises, Fish, and the Larger Crustaceans in the Waters around Denmark in Severe Winters. With 2 figures. IV. *R. Spärck:* Studies on the Biology of the Oyster (*Ostrea edulis*) VI—VIII. 109 pp. 1929.

XXXVI. I. *H. Blegvad:* Quantitative Investigations of Bottom Invertebrates in the Kattegat with Special Reference to the Plaice Food. With 1 chart and (8+6) tables. *A. C. Johansen:* The Sprat (*Clupea sprattus* L.) in the Limfjord. With 4 figures and 1 table. III. *Aage*

J. C. Jensen: On the Influence of hydrographical Factors upon the Yield of the Mackerel Fishery in the Sound. With 2 figures and 17 tables. IV. *H. Blegvad:* Aerial Spotting of Fish Shoals. Danish Experiments in 1930. With a chart. 96 pp. 1930.

XXXVII. I. *H. Blegvad:* Investigations of the Bottom Fauna at Outfalls of Drains in the Sound. With 4 figures and 2 tables. II. *Aage J. C. Jensen:* Hydrographical Investigations of the Pollution of the Sound at Copenhagen. With 4 figures and 1 table. III. *Erik M. Poulsen:* Analyses of Stock and Race of the Baltic Plaice during recent Years. With 3 figures and 3 tables. IV. *R. Spärck:* Studies on the Biology of the Oyster in the Limfjord. IX. V. *R. Spärck:* On the Capacity of Migration of Adult Individuals of *Asterias rubens*. VI. *R. Spärck & E. Lange:* Preliminary Investigation on the Content of Bacteria in the Limfjords Oyster. VII. *H. Blegvad*. On Aerial Spotting of Fish Shoals. II. Danish Experiment in 1931. With 1 chart. VIII. *H. Blegvad*: Preliminary Report on the Danish Experimental Transplantations of Plaice from the North Sea to the Belt Sea during the Years 1928– 31. With 4 figures. 94 pp. 1932.

XXXVIII. I. *H. Blegvad:* S/S "Biologen". With 14 figures. II. *Erik M. Poulsen:* Biology of the Dab in Danish Waters. With 7 figures and 23 tables. III. *R. Spärck:* Investigations on the Biology of the Oyster X. 32 pp. 1933.

XXXIX. I. *H. Blegvad:* An Epidemic Disease of the Eel-Grass *(Zostera marina* L.*)* With 1 Chart. II. *H. Blegvad:* Transplantations of Plaice from the North Sea to the Belt Sea. 1928—1933. The Scientific Survey. With 43 figures and 23 tables. 84 pp. 1934 (printed 1935).

XL. I. *Henning E. Petersen:* Preliminary Report on the Disease of the Eelgrass (*Zostera marina* L.) With 4 figures. II. *Erik M. Poulsen:* Recent Investigations into the Stock of Salmon and Sea Trout in the River Gudenaa. With 8 figures and 9 tables. III. *R. Spärck:* Investigations on the biology of the oyster XI. On the size and age-composition of the stock of native oyster in 1935. IV. *R. Spärck:* On the occurrence of *Crepidula fornicata* (L.) in the Limfjord. 44 pp. 1935.

XLI. I. *Knud Larsen:* The Distribution of the Invertebrates in the Dybsø Fjord, Their Biology and Their Importance as Fish Food. With 9 figures and 3 tables. II. *Søren Lund:* On the Production of Matter and the Growth in some Benthic Plants. With 8 figures and 6 tables. 52 pg. 1936.

XLII. I. *C. V. Otterstrøm:* On Methodical Liberations of Salmon and Trout Fry in Watercourses with Special Reference to the Gudenaa Area. With 21 figures. II. *Erik M. Poulsen:* The Dab in the Danish Waters, Investigations on Stock and Growth. With 12 figures and 6 tables. III. *Aage J. C. Jensen:* The Races of Dab in the Danish Waters. With 4 figures and 2 tables. 63 pg. 1937 (printed 1938).

XLIII. *Erik M. Poulsen:* On the Migrations and the Racial Character of the Plaice. With 10 figures and 8 tables. 80 pg. 1938 (printed 1939).

XLIV. *C.V. Otterstrøm* and *E. Steemann Nielsen:* Two Cases of Extensive Mortality in Fishes Caused by the Flagellate *Prymnesium parvum*, Carter. With 9 figures. 24 pg. 1939 (printed 1940).

XLV. *H. Blegvad:* The Danish Biological Station through 50 Years 1889—1939. With 64 figures. 69 pg. 1940 (printed 1944).

XLVI. *Erik M. Poulsen:* On Fluctuations in the Size of the Stock of Cod in the Waters within the Skaw during Recent Years. With 13 figures. 36 pg. 1941 (printed 1945).

XLVII. I. *Søren Lund:* On Colpomenia peregrina Sauv. and its Occurrence in Danish Waters. With 5 figures. II. *Knud Larsen:* The Liberation af Salmon and Trout Fry in Denmark. With 3 figures and 1 table. III. *C.V. Otterstrøm:* Turbines and Descending Salmon and Trout Smolts (and Eels): With 10 figures. IV. *Frode Bramsnæs, Mogens Jul* and *C.V. Otterstrøm:* Barriers against Fishes by Means of Veils of Air. With 3 figures. 46 pg. 1942. (printed 1945).

XLVIII. I. *H. Blegvad:* On the Waste Fish Fishery. With 2 figures and 8 tables. II. *Erik M. Poulsen:* Investigations on the Danish Fishery for and the Biology of the Norway Lobster and the Deep-sea Prawn. With 12 figures and 7 tables. III. *C.V. Otterstrøm* and *Knud Larsen:* Extensive Mortality in Trout Caused by the Infusorian Stentor polymorphus Ehrenb. With 2 figures. 57 pg. 1943—45 (printed 1946).

Printed by Bianco Luno, Copenhagen.